Off the Clock

Time's Flow, Value, and the Metric Foundations of Exchange and Duration

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DEDICATION

It is with love and admiration that I dedicate this to my parents, Berna and Myron Garron. I could not have done this without their love and support.

I also dedicate this to Laurie LaBelle, for her inspiration, patience and love.

I also thank my children, Tate, James and Caroline for the joy they give me.

Abstract

This thesis defends a dynamic view of time by drawing a sustained analogy between money and time. Neither, I argue, is merely an abstract quantity or externally grounded dimension – each is an impredicative system that derives measures of value or duration by means of self-reference. Time flows, and it does so at a rate of one second per one second. While this rate has been dismissed by some philosophers as meaningless, I argue that its structural form reveals an essential feature of temporal passage. This thesis not only seeks to rehabilitate the dynamic view of time but does so by treating money as a philosophical analogue capable of illuminating the flow of time.

Chapter 1 defends Tim Maudlin's claim that time flows meaningfully against Huw Price's objection that rates such as 'one second per one second' are tautological or nonsensical. I argue that such rates are structurally informative and consistent with how other basic measurement practices function.

In Chapter 2, I expand on the Temporal Regress Argument (TRA) introduced in Chapter 1. The TRA challenges the coherence of the dynamic view of time only if one assumes that each moment of time must be grounded in a prior or external standard. This regress mirrors a similar issue in monetary theory: if the value of money must always be grounded in something else (e.g. gold, labour, utility), a similar regress arises, which I call the Monetary Regress Argument (MRA). The problem isn't one of fundamentality. Money isn't fundamental. The problem is one of direction of fit. Any supposed more fundamental value must ground the value of money without in turn being measured.

Chapter 3 develops the MRA, applying the formal structure of the TRA to the ontology of monetary value. I argue that the value of money is not grounded externally but rather internally, by its impredicative structure – money measures value because it is defined in terms of its own purchasing power. This impredicative structure is also central to time.

In Chapter 4, I explore the ontological implications of this view. I suggest that both time and money gain important features not through reference to an external standard, but through self-reference. This explains both their universality and their role as metrics within broader social and physical systems.

Chapter 5 engages with recent positions which I collectively label the Embedded Perspective View (EPV). This holds that important features of time – like flow, passage or asymmetry – are merely features of human perspective rather than mind-independent reality. I counter this view by raising doubts about whether there can be creatures which do not experience manifest time. Likewise, I show that our money practice simply reflects the temporal asymmetry of past, present and future and the real modal change as the present becomes the past. Money isn't merely an analogue to money. Money interacts with time in a specific way.

This change suggests that time possesses structure that is irreducible to the mere appearance of manifest time for creatures like us. I argue this structure is necessary for all information gathering and utilisation systems.

Finally, Chapter 6 examines financial instruments like yield curves, which embed dynamic temporal dimensions in both axes and data points. These graphs do not just measure time; they represent it as structured flow, akin to how time manifests in lived experience and dynamic metaphysical accounts. Just as money is defined by money, time is defined by time. We can measure both only impredicativily, and both exhibit a metaphysical structure that resists reduction to static or external reference.

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Chapter 1: Introduction

Time is something that can be measured by a clock. By comparing various kinds of motions and changes, we can measure durations. We also use money to measure. Currency units, such as dollars or euros, also measure. (All instance of 'dollars' in this thesis refer to US dollars unless otherwise stated.) They measure in the same way that clocks measure, by comparing one thing with another. What dollars or euros measure is value, and they do this by comparison during a monetary exchange. In this thesis, I will argue that money must perform this measurement function owing to exchange. This requires a particular fixed relationship between money and time. I will make use of Jean Cartelier's concept of 'money hypostasis', which is a view according to which money is an entity endowed once and for all with some intrinsic, permanent properties or features. On this view, money, as such, has more or less similar effects on social relations, regardless of the society in question and regardless of what a society might value. Cartelier rejects this view. For him, there can be no general theory of money, nor can it have a unique essence or principle (Cartelier 2006, 217). In this thesis, I claim that money hypostasis occurs because of the measurement function that money performs. One type of objection that I anticipate throughout this thesis is simply the rejection of money hypostasis, as exemplified by Cartelier.

The reason I employ Cartelier's concept is that money depends on certain features of what many refer to as 'manifest time'. I will argue that the concept of money presupposes a metaphysically robust distinction between the past and the future, as well as an objective present that must be subject to change. In this thesis, I argue in favour of a general theory of money on which the essential and permanent properties of money are a result of money's measurement function. Because of this measurement, money is a useful analogue to time. Money measures exchangeable value: a dollar is exchangeable at a rate of one dollar per one dollar. Similarly, clocks measure the passage of time: a second is measured to have a duration of one second. In this thesis, I will defend the *flow of time* thesis, which maintains that a second flows at a rate of one second per one second.

There is an old adage: 'time is money'. Does anyone take this literally? The history of this comparison is interesting because the comparison seems incomplete. Isaac Newton, for instance, writes about absolute space and absolute time but nowhere does he talk about absolute money, despite the fact that he had a lot to say about both time and money. He was, after all, Warden and later Master of the Royal Mint.

It is natural to think that Newton's contribution to monetary theory can be neatly separated from his work in mathematics and physics. But the divide is not so clear-cut. Newton's views on time influenced his views on interest rates and the relationship between interest, employment and even property values (Newton 1701). Interest rates in particular will feature heavily in this thesis. These rates represent a significant type of temporal discounting and are the basis for the generation of yield curves (which will also feature heavily in this thesis).

Newton took monetary discounting seriously. This is unsurprising; as a polymath, he excelled across disciplines. There is one particular, curious connection between money and physics (in the classical sense of the science dealing with matter in motion). Newton's differential calculus (the method of 'fluxions' as he called it) had two very different applications. First, it was used to plot the orbits of the planets. At the same time Newton himself applied his calculus to determining the present value of annuities.[1] While Newton's laws of motion are time reversal invariant, the same cannot be said about the present value of annuities. In this thesis, I will build my argument in defence of a dynamic view of time on this asymmetry. This dynamism can be expressed as follows: a second flows at one second per one second.

One might think that although money can tell us something about our relationship with time, it cannot reveal much about the mind-independent nature of time. This will

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[1] Newton included present value calculations in the method of fluxions in order to demonstrate the power of infinite series and algebraic methods. In other words, representing geometric or changing quantities as algebraic expressions and manipulating them symbolically — especially via power series expansions.
 He did not use present value because present value required fluxions. He did use this example because it used infinite series. The crossover between the applicability of calculus to problems of motion and to financial problems cannot be ignored. We see Newton's interest in money and finance on full display in *Sir Isaac Newton's Tables for Renewing and Purchasing the Leases of Cathedral-Churches and Colleges* (Newton 1742). Furthermore, according to EJ Farren 'A more striking instance, perhaps, could not have been given of how completely the calculus adapts itself to the investigation of even the commonest assumptions in actuarial subjects, and thus enables us to ascertain the exact conditions with which such assumptions are really connected' (Farren 1855). Newton understood that as a consequence of lowering interest rates, land and property go up in value (Newton 1701).

constitute a significant source of the objections to my arguments for a dynamic view of time. Many physicists and scientifically minded philosophers believe in what is sometimes referred to as '*the static view*' of time (Callender; Green; Russell; Smart). This is the view that time is like space, insofar as there is no such thing as the passage of time.[2] Likewise, these same people think that money has nothing substantive to tell us about time.

Throughout this thesis, I will use the term "money practice" to refer to the socially embedded use of money as a measurement device. I will also discuss the *"measurement practice"* in general as a socially embedded practice. The use of the singular noun "practice" is technically inaccurate, because there are many such practices. To clarify, then, I use the singular term to pick out the common elements of the practice. This is why money hypostasis will be a useful concept.

So why does money come up in this discourse? It is strange for something that is supposed to be peripheral and have very little to say about time to be discussed as often as it is. The goal of this thesis is to challenge the assumption of irrelevance. I will demonstrate just how time-like money is. The asymmetry of the money practice, and the asymmetry of present valuing simply reflects the temporal asymmetry of past, present and future and the real modal change as the present becomes the past. If money is time-like then the money analogy can tell us something substantive about time.

Those who are more interested in money – economists and philosophers of social institutions, for instance – cannot afford to ignore time. The main reason for this asymmetry between physics and economics is that both these disciplines consider measurements for time, but they are measuring time in two very different ways. In physics, time is measured by clocks and what is being measured is the dimension of extension expressed as duration. In economics, time is also often measured by clocks, but it is not extension that is of interest. Rather, it is value and worth. Creatures like us

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[2] Throughout the thesis I will continue to make the distinction between static and dynamic views. I am not claiming that everyone who takes a view I describe as static will be happy with this assessment. Still, I think the label is appropriate. What I mean to imply with the label 'static view' is that the particular view can claim a certain lineage to Bertrand Russell's 'At-At' view of time. According to Russell, 'Weierstrass, by strictly banishing all infinitesimals, has at last shown that we live in an unchanging world, and that the arrow, at every moment of its flight, is truly at rest' (Russell 2009, 353). Russell refers to his analysis as the 'static theory of change'. When I speak of a static theory, I am referring to a theory whose lineage can be traced back to this view of change. This is also why McTchange is a useful contrast term. I use this distinction throughout the project.

value the 'time of our lives'. As Jim Morrison once decried, '(you) trade in your hours for a handful of dimes'. This dual way of measuring is why money seems to be a recurring but often peripheral part of the discourse on physical time. In this thesis, I will offer an explanation of why measuring value is similar to measuring duration. Throughout this thesis, I argue that the money practice, in the way that it measures, can be universalised to fundamental measures of extension such as metres and seconds. For this reason, money should not be merely peripheral to the discourse on time, but instead front and centre. The money practice says something about our relationship with time, and I will argue that this relationship includes fundamental measurements.

To be clear, I am not claiming that money is a fundamental measure of reality. The dollar will not be included in the SI units any time soon. So, what does this statement, 'time is money' mean? Why should we care about money when we are talking about the nature of time? I think that what this adage is saying is that, practically speaking, we should treat our time as though it was as valuable as money, and that to some extent it is convertible into money. What I will demonstrate in this thesis is that money is an interesting example of the measuring practice.[3] I will establish that the measurement practice is a frame-dependent practice. The dollar, as an example of all currency units, constitutes a measurement instrument in its own right. Below are a series of quotations that discuss measuring time and money. There seem to be two distinct ways of measuring. In the case of money, there is a comparison between one thing and another in exchange. In the other context, the comparison is between some motion and what one might call the pure passage of time. I bring these up in this introduction to underscore the long history of this discourse concerning time and money. It is curious just how often philosophers who are interested in time also have something to say about money. Let us consider some of those philosophers here.

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[3] Our measurement practice consists of two important processes: first, a physical process involving interactions between an object of interest, such as an instrument as a gauge, and the environment; and second, a theoretical and/or statistical model of that process. This model consists of an abstract idealised measure and a local representation. The measurement practice selects for ever more accurate, and therefore more abstract and idealised, units of measure. In the case of the measurement involved in the money practice, while physical practices take place, it can be difficult to determine just exactly where they are.

Plato:

> Do things of the same size appear to you larger when seen near at hand and smaller when seen from a distance? ... If, then, our well-being depended upon this doing and choosing large things, avoiding and not doing the small ones, what would we see as our salvation in life? ... The art of measurement ... would make appearances lose their power ... (Plato 1997)(356c–e)

In this quotation from the *Protagoras*, Plato speaks specifically of value. He does not mention money explicitly, but rather draws our attention to our need to measure in order to make good choices. If we want to choose larger goods, we need the art of measurement. It is the money practice that allows for this sort of measurement. Just as a ruler, as a gauge, allows us to choose bigger objects, one needs a measure to choose greater values.

Aristotle

> **Time**: [C]hange is always faster or slower, whereas time is not; for fast and slow are defined by time—fast is what moves much in a short time, slow what moves little in a long time; but time is not defined by time. (Aristotle 2014b, 218b15–18)

> **Money**: Now by wealth we mean all the things whose value is measured by money. (Aristotle 2014b, 1119b20)

> There must, then, be a unit, and that fixed by agreement (for which reason it is called money); for it is this that makes all things commensurate, since all things are measured by money. (Aristotle 2014b, 1133a7–1133b28)

These passages offer examples of the distinct ways in which we measure with time as opposed to money. We do not fix the passage of time by convention, and time is not defined by time. Aristotle gives a specific answer to the question of what art of measurement we need for value. Money creates a common measure between things we value. What is curious in Aristotle's account is the different way he treats time compared with wealth. Time is not defined by time, but money is defined by money. Money is surely one among 'all things measured by money'.

Locke

> **Time:** [N]otwithstanding that that duration might be measured by motion, yet in itself it is wholly separated from it and is a distinct thing. (Locke 1824)

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We must therefore carefully distinguish betwixt Duration itself, and the measures we make use of to judge its length. Duration in itself is to be considered, as going on in one constant equal uniform Course; but none of the measures of it we can make use of can be known to do so. (Locke 1854, 311)

Money: This proportion in all commodities, whereof money is one, is the proportion of their quantity to the vent. The vent is nothing else but the passing of commodities from one owner to another, in exchange ...Money, whilst the same quantity of it is passing up and down the kingdom in trade, is really a standing measure of the falling and rising value of other things, in reference to one another: and the alteration of price is truly in them only... men consider and speak of it still, as if it were a standing measure, though when it has varied its quantity, it is plain it is not'. (Locke 1714, 22)

For Locke as well as Aristotle there is a divergence between how we conceive the measurement function of money and how we measure time. Time is thought of as something other than motion, while money is one commodity among many. We may think of it as unchanging, as a standing measure, but in fact it is not. This raises a question: Why must we think of time as a standing measure, but not money?

Newton

Time: Absolute, true, and mathematical time, of itself, and from its own nature[4] flows equably without regard to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by the means of motion. (Newton 1687, 77)

Money: For paper credit or to speak more paper security if it be good is of the same value with good money. If security upon a Bond or Mortgage or Bill of Exchange or a Bank Bill be good, its [sic] as good as money... Tis mere opinion that sets a value upon money; we value it because with it we can purchase all sorts of commodities & money too. (Newton 1701, 6311)

With Newton, we see in more stark terms the difference between the measurement of time and the measurement function of money. Newton thinks that it might be possible to find a perfect 'standing measure' for time – by finding an equable motion. Time is measured by motions and changes, but there is a distinction between

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[4] It is worth remembering that Newton wrote this in Latin. '*Tempus absolutum verum & Mathematicum, in se & natura sua absq; relatione ad externum quodvis, æquabiliter fluit, alioq; nomine dicitur Duratio; relativum apparens & vulgare est sensibilis & externa quævis Durationis per motum mensura, (seu accurata seu inæquabilis) qua vulgus vice veri temporis utitur; ut Hora, Dies, Mensis, Annus'* (Newton 2022). It might be a reasonable translation of '*in se*' to '*in and of itself*'.

time as true and mathematical and time as common and apparent. Some claim that time is a *sui generis* kind of change.[5] Money, however, is valued because of the things you can get by its use, among which is money itself. In this quotation, Newton treats money purely endogenously.

Simmel

There is no more striking symbol of the completely dynamic character of the world than that of money. The meaning of money lies in the fact that it will be given away. When money stands still, it is no longer money according to its specific value and significance. (Simmel 2005)

It is notable that Simmel's interest is directed almost exclusively at money, but this leads him to make some strong claims about time. Simmel's approach differs from that of Plato, Aristotle, Locke and Newton. Simmel is drawing conclusions about time from the money practice. This will be my strategy in this thesis. I will show how money functions as a measurement. What I will achieve is a practical demonstration of a self-referential measurement system. I will refer to self-reference in measurement as **'impredicativity'**.

What Simmel shows us is that there is no fixed standpoint. Money's value is in flux, as are the things whose value it measures, yet it is also a measure that we make significant use of in our daily lives. This is precisely what Locke brings to our attention when he says that money is seen as a standing measure but clearly it is not.

This brings us to a very recent comparison between time and money:

Maudlin

What, then, is a fair rate of exchange of dollars for dollars? Obviously, and necessarily, and a priori, one dollar per dollar. If you think that this answer is meaningless, imagine your reaction to an offer of exchange at any other rate. (Maudlin 2007, 112)

Price

Maudlin's exchange rate example misses this point, because it provides two things to tally: the dollars you give me, and the dollars I give you. (Price 2011b, 304)

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[5] According to Isaac Barrow, Newton's teacher, '[t]ime flows perpetually with an equal Tenor', but this even tenor defies measurement because, in order to find quantity, we are obliged to invoke motion in order to esteem and compare (Barrow 1735, 7).

It is this exchange between Maudlin and Price that motivated my argument in this thesis. This is why I have grouped Maudlin and Price together. Maudlin defends the view that time flows at a rate of 'one second per one second'. Likewise, there is a common-sense belief that a dollar is worth a dollar. This exchange seems to have stumbled on the very same difference in the measurement practice between time and money that we see with Aristotle, Locke and Newton. In contrast, Price, like Aristotle, Locke and Newton, thinks that time is different than money in one respect: Money consists of units of measure which are exchanged for other units of measure, whereas measures of duration are not. According to Price, there are not two things to tally.

But this exchange between Maudlin and Price seems incomplete. Part of my goal is to complete this comparison and to show that Price's response does not work.

Callender

Money, too, makes life much easier than negotiating a barter transaction every time you want to buy coffee. But it is an invented placeholder for the things we value, not something we value in and of itself. Similarly, time allows us to relate physical systems to one another without trying to figure out exactly how a glacier relates to a baseball. But it, too, is a convenient fiction that no more exists fundamentally in the natural world than money does. (Callender 2010, 65)

This quotation from Callender illustrates the peripheral way in which money is typically treated. Money is often brought up when discussing time. It is cited as an example in one-off comparisons without much further discussion. Often the conversation ends abruptly, as in the exchange between Maudlin and Price. Callender thinks that money is a useful fiction that has no intrinsic value, and that we should think that time is also like money: a useful fiction but dispensable at the fundamental level. He suggests that it is self-evident that money has no value *in and of itself*. I suggest that this generates a regress argument. Likewise, time seems to be reducible to the interrelation of all kinds of other movements and changes. These are practically useful structural relations" rather than exhaustive ontological truths. For this reason, time does not have properties such as flow or passage *in and of itself*. In this thesis, I will turn the tables around. The things that money measures such as wealth and purchasing power are perfectly real and objective things in the world even if they depend on humans for their existence. Based on this, I will also argue that money demonstrates just what is dynamic about time.

This thesis will begin with the dispute between Maudlin and Price. Price, like many who defend the 'static view', thinks that dynamic time just does not make sense. As Aristotle puzzled over, change is always faster or slower, but time defines what is fast or slow. This means that time is neither movement nor independent of movement. It is precisely this conflict that led to the various regress arguments concerning time in the 20th century. In Chapter 2, I will construct such a regress argument. I will then show that money has analogous regressive structures. I will then apply the same argument structure to money. In Chapter 3, I will answer the question of whether money, and more specifically currency units like the dollar, suffers from the same conceptual defect as the flow of time. This, I claim, is what lies behind Callender's 'in and of itself' claim. The analogy is simple. If the notion that time flows is incoherent owing to the regress argument, then currency units, like the dollar, are also worthless owing to an analogous regress argument. I will argue that money is not worthless, it just is not valued exogenously (by referring to a more fundamental value) nor *in and of itself*(intrinsic value). Money is valued endogenously. Endogeneity means that money is backed by the very same economy that it measures. Hence money is not worthless and the flow of time is real. Like money, the rate at which time flows is measurable endogenously. What the money regress argument will show is that the direction of fit is bidirectional. The things that ground the value of money are measured and valued by money. Hence the regress argument fails.

In Chapter 4, I shift my focus to the ontology of money. It is curious that both Locke and Newton treat money differently from time. I will establish that this differential treatment of time and money is not justified. Here is where my borrowing of money hypostasis will be useful. Money produces more or less similar effects on social relations, regardless of the society in question. Money constitutes an impredicative means of measurement. I will argue that the measurement of time can likewise be construed as impredicative.

In Chapter 5, I will examine a few possible replies to my analysis of these regress arguments from what I refer to as the embedded perspective. Callender's statement about money is applicable here. He claims that money is an invented placeholder, and in a sense I agree: it is a product of the money practice, and this can be purely unintentional among the participants. This is demonstrated both by new forms of currency coming into

being, such as bitcoin and older currencies ceasing to act as currency, such as Deutsche Marks. Furthermore, it does seem that we do something similar with motions. We compare one motion with another by the use of time as an intermediary. The important distinction in the senses of 'placeholder' comes from the measurement practice. As I said earlier, I am turning the tables here. I will argue that, because money is not just a convenient fiction, these two similarities between time and money bolster the reality of time. We can purchase all kinds of things with money – including money. This is why we value it. My main response to the embedded perspective is to argue that money is neither merely cultural nor merely anthropocentric. So, I will argue, the belief in an unfolding future is necessary for concepts like earning, saving, or spending of money. I will argue further that this applies to all information gathering and utilisation systems.[6] This view of time that money represents can't be merely anthropocentric. It must apply to all information gathering and utilisation systems.

This still leaves the thesis half-finished. What is missing is an account of just what is supposed to be dynamic about time. I have to address the puzzlement expressed in Aristotle's assertion: time is neither movement nor independent of movement. If I say that time flows at a rate of 'one second per one second', then I am also saying that time is movement and not independent of movement. I defend this stance, but in doing so I find in the money practice a representation of the flow of time that involves multiple temporal dimensions; these dimensions flow in relation to each other. These representations are typical yield curves. By the end of Chapter 6, I will have established that yield curves represent dynamism both in the graphs and in the axes (scales or temporal dimensions) themselves. Time, like money, is impredicative. It is self-measuring. Just as money is defined by money, time is defined by time.

So far, I have stated what I intend to address in this thesis. For the sake of clarity, it is worth also stating what I intend not to address. My targets for this thesis are views that deny that time flows as a result of some sort of conceptual incoherence. That aside, I recognize that my arguments here may not be convincing for someone, who has B-

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[6] I am using 'belief' in a broad context. To a large extent, I am translating behaviour into belief terms. Markets behave in ways similar to how belief-guided actors do, but is unclear how much we can ascribe genuine market beliefs when we talk about market expectations. Nonetheless, we can and often do take a stance that there are market expectations.

theoretic, 'physics first' deflationist sympathies. While 'conceptual incoherence' is a significant motivator for the B-theoretic deflationist view, refuting 'conceptual incoherence' still leaves the plausibility that all legitimate temporal facts can already be expressed as semantic, psychological, or illusory. In addition, what Braddon-Mitchell and Miller call strongly timeless theories (Braddon-Mitchell and Miller 2019) are also outside the scope of this thesis. One of the first to deny the existence of time was the 5th-century BC presocratic philosopher Parmenides. There are more recent strongly timeless theories such as Julian Barbour and Max Tegmark. My thesis will not address these views and figures, even though they also deny that time flows (Hattiangadi 1978; Tegmark 2014; Barbour 2001).

Chapter 2: Measurement is bidirectional

Wittgenstein's Ruler: "Unless you have confidence in the ruler's reliability, if you use a ruler to measure a table you may also be using the table to measure the ruler." (Taleb 2016)

2.0 Introduction

According to J. M. E. McTaggart there are various degrees of time realism that correspond to realist views about what he refers to as the A series, B series and C series. According to the McTaggart tradition, A-theorists believe in the A series and that time flows and it is made up of three distinct parts, the past, the present and the future (McTaggart 1908). The flow of time is most commonly construed as moving from the past into the future. The concept of time flow involves two further claims: time is dynamic, and time is directed. I take this view. In contrast, B-theorists, as well as other anti-realists about time, say that if time flows, it must flow at some rate. This implies that these two A-theoretic properties, dynamism and directedness, are measurable. We use time to measure dynamism and directedness and thereby determine rates such as rates of speed. Accordingly, if time is dynamic and directed then it needs something else other than time to compare to derive rates. We must regress so to speak to some other thing to compare to time. This is the heart of the rate regress problem.

In this thesis, I argue that these rate regress arguments are flawed. They presume that the rate of time's flow is an absolute quantity, yet they also claim that it can only be deduced by a relative comparison of one thing to another. Those who disbelieve that time flows claim there are at least three problems with such a regress: it is ontologically explosive, systematically ambiguous and non-sensible. It is ontologically explosive because we need to posit more and more time like things to compare. There need to be more time scales or time dimensions. Likewise, there is systemic ambiguity because it is unclear what constitutes the fundamental rate every time an additional time like thing is introduced or posited for comparison. It is nonsensible because all we can compare time to are motions that time already measures. If there are any further time dimensions or time scales there don't seem to be any clocks to measure them.

A-theorists typically reply to the rate regress arguments in two ways. One way is to say that time does flow at a rate, and that rate is 'one second per one second'. The other is to claim that the flow of time is a *sui generis* process. It cannot be analysed by making reference to something else. Opponents of the flow of time are critical of the first strategy because it commits the sin of self-reference. I will refer to this as the 'very same thing' argument. Likewise, they are critical of the second strategy because it commits the sin of *'non-sensibleness'*. In this chapter, I will remain agnostic as to whether the '*sui generis*' strategy is successful. In the money example that I will explore, there is a sense in which there is an analogue to an absolute quantity when we refer to any currency unit, but determining this through our exchange practice seems *'non-sensible'*. Quantities are ontologically prior to the procedures that measure them. There may not be an equable measure of the '*sui generis*' process that is the flow of time, even though, as Newton points out, apparent and common time is a sensible and external measure of duration (Newton 1687, 77).

My goal in this chapter is to show the shortcomings of the 'very same thing' argument. By the end of this chapter, if I have done my job, the reader will understand what the 'very same thing' argument is, and how it fits into the debate concerning the rate of the flow of time. In this thesis, I defend the view that money is, ontologically, a metric. This seems in my view to imply that there is again money hypostasis: money so construed is something with permanent features.[7] Equality of units is a critical component of establishing measurement frames. Since our money practice is part of our measurement practice, currency units are like measurement units such as seconds and metres. In the money practice, the exchange where one dollar is worth one dollar coincides with the uniqueness of the present. The 'now' or present has a substantive epistemic status. It grounds the money practice as part of the measurement practice. The things that money measures can be represented in a ratio scale where units start at a 'zero-starting point'. The 'zero-starting point' corresponds with the absence of the variable being measured (Ho 2013, 8). The present, in a representation such as a yield curve, establishes a 'zero-

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[7] The money hypostasis is not a settled matter. There are alternative views. Some claim that there can be a wide variety of money types and that money is always context-dependent. For example, Jean Cartelier thinks that 'each particular money is embedded in a social context out of which it is almost impossible to interpret'(Cartelier 2006, 1). He claims that economists are more subject to money hypostasis than anthropologists. In this thesis, I come down on the side of economics.

starting point' because the important discounting variable of duration is absent. This is because, in our discounting practice, we reciprocally value money based on the variable of duration.

I will make use of a 'zero-starting point' in later chapters. In physics, frames of reference set a standard by which motions and rest maybe measured. In the money practice, the 'zero-starting point' represents a reference to a 'now' or 'present'.

2.1 Rates

This chapter began with the objection that if time flows then it must flow at a rate. Therefore, our natural starting point is to ask some questions about rates.

These questions are as follows.

1. What is a rate?
2. Why does the claim that time flows require a rate of flow[8]?
3. What is the right sort of rate required to manifest flux or dynamism?
4. Would such a rate describe some metaphysical property, or is it just a doxastic or epistemic description?
5. Can there be flux or dynamism but no rate of this flux?

The standard objection to the flow of time is that if time flows then it must flow at a rate. According to Huw Price:

I take to be most characteristic of the notion of flux – is that it is something to which a rate may sensibly be attached. (Price 2011b, 302)

The objection can be parsed in two ways.

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[8] Before we begin, throughout the literature there are two descriptive words used, passage and flow. Flow is a verb in active voice. There is also another expression, 'becoming' or 'pure becoming'. 'Becoming' is a verb in passive voice. I will use the term 'passage' when discussing those who use that term. However, I think they refer to the same phenomenon. My preference is to use the more descriptive and active voice verb 'flow'. I do not go into detail about my reasons, other than to say that 'flow', in my view, is more congruent with both ancient and Newtonian terminology. However, this is not the preferred word for many defenders of passage. Maudlin, for instance says the following: 'The notion of the passage of time is discussed under the rubric "time's flow", or "the moving now". These locutions tend to be favoured by authors intent on dismissing the notion, and certainly subserve that purpose' (Maudlin 2002, 260). According to Maudlin, 'properly speaking, if anything flows it does so because time passes' (Maudlin 2007, 114). He thinks that flow overly emphasis the river metaphor. I disagree, and think 'passing' implies something like the 'one thing relative to another' view. I use the locution 'flow of time', not to undermine the reality of temporal passage, but to bolster it. I think that 'flow' captures the continuous generation of quantities with instantaneous rates of flow within a continuously flowing time. In Chapter 6, we will examine the concept of an instantaneous interest rate, and how this rate can fit into our overall scheme.

P1: The flow of time must be expressible as a rate (Prior and Hasle 2003, 7; Romero 2018, 136; Price 2011b; Smart 1949).[9]

P2: The flow of time must be expressible as the right sort of rate.[10]

Defenders of time flow often accept P1 (Arthur 2019; Markosian 1993; Maudlin 2015; Miller and Norton 2021; Skow 2012). One strategy is to claim that there is a rate, and that rate is 'one second per one second' (Maudlin 2015; Skow 2012).

Another strategy is to simply reject P1. For example, according to Graeme Forbes, 'the sense of change we are after is not to be analysed in terms of variation of one thing relative to another' (Forbes 2025). On this view, there is not anything like speed-through-time. This is the *sui generis* approach.

Another A-theory-like account of time's flow is flow fragmentalism. This view finds common ground with both the A-theory and the B-theory: it agrees with the A-theory that there are temporal facts that obtain but do not 'always' obtain, and agrees with B-theory by holding that no moment or interval of time is privileged or more real than any other. Fragmentalism can maintain a B-theoretic, 'physics first' deflationist explanation of the "dynamic" features of time using, linguistics, psychology and cognitive science rather than ontology. Taking inspiration from Kit Fine's non-standard tense realism, flow fragmentalism defends the view that instances are past, present or future relative to each other and are not mere metaphors of tenseless facts. [11] In the fragmentalist picture, there is no absolute 'now' that moves along the series of fragments, and hence there is no need

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[9] If we accept P1, then the thought is that the flow of time is vulnerable to arguments which claim that there can be no such rate. This constitutes what Raven calls the 'no rate' argument (NRA) (Raven 2011).

[10] An example of this 'right sort of rate' approach is the no alternative possibility argument (NAP), which goes as follows:

P1: If x passes, then the rate at which x passes could be different.
P2: Time cannot pass at a rate other than 1s/s
Therefore, C3.:Time does not pass (Tallant 2016, 36).

This strategy accepts that 1s/s is a rate, but claims that is the wrong sort of rate for time to pass(flow). I think this is better described as 'the wrong sort of rate' argument.

[11] According to Fine, there are two options for the non-standard tense realist. The relativist account and the fragmentalist account. The relativist account gives the idea that reality is absolute. The fragmentalist gives up the idea that reality is a single coherent whole. Rather reality is made up of fragments no two of which can be regarded as belonging to a single coherent whole (Fine 2010, 262).

If, as some argue, truth-predicates are tenseless and timeless, then one might therefore claim that expressions such as "obtains" are also tenseless and timeless. One set of facts at one time becoming another set of facts at another time is merely a metaphor. There is after all, in this picture, no becoming and no obtaining.

for what Bradford Skow refers to as 'supertime' or what George Schlesinger calls 'meta-time' (Torrengo and Iaquinto 2020, 11; Schlesinger 1991, 431) (Skow 2011). The 'supertime' strategy according to Skow's investigation, is that flow or passage of time—if it exists—requires a second temporal dimension. This dimension, he calls supertime. It would be the arena in which the "moving present" moves. We will return to 'supertime' or 'meta-time'.

For the fragmentalist, flow is not motion as such but rather 'a coherent order' (Torrengo and Iaquinto 2019, 6). This is why I think that 'flow' is a better descriptor than 'passage' – it implies a sense of connection, as when we say that a story or an essay is well written. This connection is often overshadowed by claims of dynamism and should not be dismissed as mere metaphor.[12]

I do not think the 'one thing relative to another' and *'sui generis'* strategies are mutually exclusive. If P2 places excessively strict constraints on what the rate of time's flow could be, this results in a P1 that can be easily rejected, not just in the context of flowing time but examples such as money and our typical money practices.[13] In this thesis, I will argue that the seemingly contradictory '*sui generis'* arguments of Broad and Forbes and the '*one second per one second*' views of Maudlin and Skow can be reconciled by distinguishing which claims being made are perspectival and which are non-perspectival. The example of money should also bolster the fragmentalist position.

Taking a perspective involves determining a frame of reference: a standard relative to which motion and rest may be measured. If we accept that quantities are ontologically prior to the procedures that measure them, and if these procedures always measure 'one

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[12] In Chapter 6, we will return to flow fragmentalism. When we examine any yield curve, we will see that each yield curve depicts a unique 'zero-starting point' (the point in which any currency unit is equal to itself). This has the strange result that that yield curves lack coherence. Flow fragmentalism is an interesting avenue for further research, but discussing it in detail is outside the scope of this thesis, and it is not the main challenge to flow.

[13] Certain units such as metres are defined conventionally. They are abstractions from our measurement practice. We use whatever gauge that can stand in for the metre to measure length. We do not use some length to measure the metre. When it comes to time, we measure durations with gauges that stand in for units of time. For example, second hands on a clock measure out durations of one second. We adjust the abstract units to achieve greater clarity, consistency, and accuracy. But this measuring is done in one direction. Seconds are measured by clocks. So, when it comes to a rate for the passage of time, the form of the rate is expected to be different. Skow describes this rate are follows: 'This rate is not a value of speed but is a value of some other quantity. Let us call this quantity "speed-through-time." Now whether there is any such quantity as speed-through-time in the first place is an important question. But let us for now grant that there is' (Skow 2012, 9).

thing relative to another', then in a sense these quantities are beyond our measuring practice. This is again where money presents an interesting analogy. The money practice picks out a particular present moment as the 'zero-starting point', at which point one applies monetary discounting. This differs from the causal representations in physics. In physics an event can be represented as having past and future light cones. Events falling with in either of these cones can be described as having time-like separation. They may be causally connected. In the money practice, there is no equivalent of past time-like separation, and for this reason money is not time-invariant.

In answering questions #2 and #5 we will encounter a version of dynamism in which there is no clear way of sensibly attaching a rate. Even if one accepts P1, one must still provide an analysis of what could constitute the right kind of rate. Answering questions #1 and #3 requires us to ask further questions: what is this characteristic that Price demands, and what does it mean for a rate to be *sensibly* attached to the flow of time such that this notion of flux is made obvious? To answer these, we must first clarify a few key terms. Then, we must lay out the regress and paradox arguments that have beset the time flow thesis. Finally, I will propose three examples. These examples will help us understand the short comings of 'the very same thing' argument and contextualise the 'one thing relative to another' position.

The first example is an ice hockey game. With this example I hope to illustrate that the passage of the game at certain times passes at a rate of 'one second per one second', and at other times it does not. This will help us analyse whether we are comparing the same thing to itself or instead comparing two different things.

The second example involves the exchange of goods in a butcher's shop. Here, cuts of meat are exchanged at a rate of kilograms per unit of currency, in this case pounds sterling. The puzzle is that in this context, price per kilogram works like a dimensionless constant based on the type of cuts: It is a bare number, as such it is a dimensionless quantity in this narrow context. it is the fluctuation of the weight of the cuts that determines the price you pay. However, there is also a dimension of analysis for price per kilogram based on the type of cuts. At this level of analysis, price per kilogram is *not a*

dimensionless quantity.[14] The main point of this example is to show how our choices frame the measurement practice.

The third example involves cricket. If we ask who batted the fastest century in test cricket, in this context, 'fastest' doesn't refer to time nor distance. In rate terms, we can ask: how fast does a cricket match pass? One of the answers might very well be: at a rate of one ball bowled per one ball bowled. Can we draw an analogy with time? If so, what does this say about a sensible reference to a clock when applied to the passage of the cricket match?

What I expect these examples to illustrate is that each occurrence of 'second' in the rate 'one second per one second' can in some contexts refer to two distinct things and in others to the 'very same thing'. I also intend to illustrate how there are also contexts in which we treat different occurrences of the word 'pound' as referring to different things and others where we treat it as referring to the very same thing.

2.2 The Temporal Regress Argument (TRA)

In this section I propose a more robust answer to question #1. What seems uncontroversial is that rates are a type of ratio. Both rates and ratios compare two things. But the distinction between these things is not straightforward. Sometimes this distinction gets 'cancelled out'. What is left is simply a quantity without a dimension, that is, a scale or dimension of analysis.[15] One example where the ratio stands on its own without any relationship to whatever quantities were used to derive it is the irrational number π. We treat this ratio as a bare number.

In other cases, the elimination of a scale or dimension of analysis establishes a frame of reference and involves identity claims. There are good reasons to think that 'dimension' has become a confused concept. It is ambiguous whether dimensionality concerns our measurements or some reality independent of them. Newton was careful to distinguish between extension and dimension. He uses the word 'dimension' when

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[14] Bradford Skow makes a similar observation about strain. According to him, it 'is dimensionless in the length-duration-mass class, but we could adopt a system from the class of systems that measure length, duration, mass, **and** strain in fundamental units. Strain is not dimensionless in this system (Skow 2012, 7).'
[15] In this thesis we must make a careful distinction between 'dimensions of extension', such as length and duration, and 'dimensions of analysis', which refers merely to a scale for the purposes of comparison. For example, speed can be expressed as a dimension, but this representation should not be conflated with a more fundamental unit, such as the three dimensions of space and the one dimension of time.

referring to our measurement practice (Newton 1687, 77, 154, 516). Extension, on the other hand, is independent of our measurement practices, even though we are only aware of extension through our senses (Newton 1687, 384). By Immanuel Kant's time, dimensions, particularly as they are displayed as scales in Cartesian coordinate representations, became synonymous with extension itself (Kant 1998, A40-A41 B47). Kant goes as far as to claim that 'we cannot represent the three dimensions of space at all without placing three lines perpendicular to each other at the same point' (Kant 1998, A40-A41 B154). The important conceptual presumption here is that we must stipulate a coordinate origin for our representation of space. This point, as origin, is the point in which each spatial coordinate is equal to zero. It functions as a 'zero-starting point', and all extension has an orthogonal relationship to this 'zero-starting point'.

This is all well and good for Newtonian spacetime, where all distances and duration are invariant. However, in the context of relativity theory, many measurements become frame dependent. Events are separated from each other in three ways: time-like separation, in which they may stand in causal relations; light-like or null separation, which also allows for causal relations; and space-like separation, in which they cannot stand in causal relations. This is the standard light cone structure. It is now commonplace to represent 'events' as having orthogonal relationships with the lines that divide time-like and space-like separated events. Each direction along the light cone is orthogonal to itself (Knox and Wilson 2021, 63).

In this framework, choice of a representation origin becomes important, and measurement is no longer a foundational concept. Yet it is common to talk about Minkowski spacetime as consisting of four dimensions instead of four extensions with dimensions of extension. Here we must carefully distinguish whether we are talking about our measurements or about something more fundamental, like the dimension of extension.

The important take-away is that in our space and time measurements, units need to be relativised to a particular frame. In these cases, the underlying units do not cancel out, but are integral to the meaning of the representation.[16] In this thesis, I will argue that

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[16] James Van Cleve has this to say about ratios and rates. "We do not avoid the question of units by saying that just as an absolute length is a length not consisting in a ratio to the length of anything else, so an absolute rate is a rate not consisting in a ratio to the rate of anything else. That is true; but a rate is already

expressions such as 'one dollar per one dollar' and 'one second per one second' say things about the identity of the thing being analysed. These expressions form part of the frame of reference which allows for measurement. Hence, measurement is relativised to a particular frame of reference. In the case of money, this will become clear when we look at yield curves in the Chapter 6. Interestingly, yield curves must also pick out a 'zero-starting point'. This will become relevant in my argument for dynamism. However, at this stage our goal is to give an account of rates.

What we need to do is determine when our unit terms, like 'second' and 'pound sterling', refer to two separate things and when they refer to the exact same thing. We must thus contextualise P1 and P2 in Price's objection in these terms in order to determine what is at stake in the debate over time's flow.

One significant objection to flow is that dynamic views of time are typically committed to the claim that 'time passes' (Tallant 2016, 35). Denying flow implies a denial of the dynamic view, and thereby a denial of the most significant distinction between time and space. In this thesis, I will accept this line of argument. There are nonetheless some, such as Jonathan Tallant, who propose that the dynamic view is not committed to temporal passage. In this thesis I will not look for a source of dynamism anywhere other than this passage or flow.

The rate of flow of time enters the debate over time primarily via the Temporal Regress Argument (TRA). This argument holds that things that move or change or have dynamic properties must be described as changing in relation to some duration of time. Speed, for example, is an expression of changes in location over some interval of time. The dimension of speed is thus the ratio of a distance, expressed by a unit such as 'kilometre', to a set interval of time, expressed by a unit such as 'hour'.[17] The claim is that if the passage or flow of time is like a speed, then it is reasonable to ask what the rate of this temporal 'speed' is. The natural response, according to defenders of the TRA, is to

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a ratio, so an absolute rate, though not consisting in a ratio or comparison to any ratio, is still a ratio"(Van Cleve 2011, 156). Van Cleve adds a further footnote "Does it consist in a ratio to itself? No; it bears a ratio to itself, namely unity, but it does not consist in its so bearing." Supposedly the distinction between consisting of and bearing is enough to give us what we need, namely a rate of one second per second. This idea of unity, I think is important.

[17] In the above description I am assuming rectilinear motion. Displacement differs from distance when we are no longer considering a straight line. Velocity is thus always either equal to or less than speed; see footnote 19 for more details.

posit a second time-dimension. Just as change in location is compared to a scale of time, the change in temporal location needs to be compared to some other commensurable quantity. The big question is: how comparable are these two quantities? Does this comparison require a scale? Does it require a fundamental dimension of extension? My view is that neither is necessary.

The TRA is defended by philosophers such as J.W. Dunne, C.D. Broad, J.C.C Smart and more recently Huw Price (Broad, 1938; Dunne 1929; Olson 2009; Price 1997; Smart 1949).[18] Price characterises this objection as follows: 'If it made sense to say that time flows then it would make sense to ask how fast it flows, which doesn't seem to be a sensible question' (Price 1997, 13). At this point it is worth nailing down just what sort of work 'sensible' is doing in this objection. One standard pragmatic question is, 'what else changes, if this changes?' (Price 2007, 25). The thought is that if nothing else changes, then the supposed 'change' is not sensible. The hurdle posed by this objection for the defenders of flowing time is thus to provide just such a difference.

It is worth recognising that sense-making can often be purely a philosophical hurdle that physicists might not prioritise. As the physicist Sean Carroll explains, "physicists like myself are often very happy just to get a theory that works, a theory that makes sense is a little bit too much to ask sometimes" (The Great Courses 2018)." According to the TRA and Price's criteria of sensibleness, the question of the rate of time's flow is not 'sensible' because the 'how fast' question implies a speed or a velocity. But speed or velocity necessarily involves comparing fundamental dimensions of spatial extension with time.[19]

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[18] C.D Broad's formulation differs from the rest. He used the TRA to argue against rate analysis, and thus as a challenge to P1. He claimed that to expect a rate is to conflate changes of things and changes in time: 'the changes of events or of moments from future, through present to past, is a change of time... We can hardly expect to reduce changes of Time to changes in Time, since Time would then need another Time to change in, and so on to infinity' (Broad 2014, 63).

[19] It is worth noting that speed is not the same as velocity. According to standard definitions of speed, it is a scalar, quantity. Velocity on the other hand is a vector quantity. A change of position is required (Pandey 2021). A good example to illustrate this difference is the cycles of an electric current. AC in the UK has a frequency of 50 HZ ("What Is Frequency? | ESO" 2025). Current is generated by rotating a magnet. The speed of that rotation is 50 cycles per second. The velocity of the propagation of the electric wave that results however is at close to the speed of light. When it comes to time, there is an interesting issue. If time is one dimension that is different from space, and if time has a direction, then we can ask whether the flow of time is a velocity or a speed. Since the displacement takes place in only one direction, (if one accepts that time has a direction) then it is reasonable to ask about times velocity. One might claim that the flux of time is like a current, but this does not seem to capture the sort of flow that defenders of flow have in mind. Time running backwards and forwards all the time does not lead to much explanatory power.

If time is supposed to be dynamic, then it is reasonable to expect it to have a speed, or even a velocity. How can this be made 'sensible' without obtaining obvious contradictions? Moreover, how can we possibly measure this rate? The answer seems to be: in comparison to another quantity. According to Ned Markosian (1993, 839), for any x, if x changes, then x changes at some rate. The quantity that x represents needs to be compared to something. He breaks this down into the two sub-strategies we encountered earlier. The first is to accept that 'the passage of time is a change whose rate may be measured with respect to itself, so that there is no need for me to posit any second time-dimension'. The second strategy is to reject measurement entirely: 'The passage of time is a change whose rate simply cannot be measured, so that there is no need to posit any second time-dimension" (Markosian 1993, 843). Broad and Forbes employ this second strategy. Accordingly, trying to determine the rate of passage of time involves a category error. This is important for the argument of this thesis, as a large part of the project is to determine whether time can be compared to itself. My answer is ambivalent: sometimes it can, sometimes it cannot. We must look at examples and the work being done by measurement. In employing these examples, I'm following Markosian's first strategy. This approach makes time closely analogous to money. Self-reference and self-measurement are baked into our money practice.

The TRA argument seems to have originated with Dunne (1929), but Smart's seminal paper 'The River of Time' cemented the TRA as a daunting hurdle that any explanation of the passage or flow of time needs to clear. According to Smart:

> If time is a flowing river we must think of events taking time to float down this stream, and if we say "time has flown faster to-day than it flew yesterday" we are saying that the stream flowed a greater distance to-day than it did in the same time yesterday. That is, we are postulating a second time-scale with respect to which the flow of events along the first time-dimension is measured. (Smart 1949, 484)

Smart's description lays out in simple language the basic commitments of the TRA. We can summarise this more explicitly as follows. Recall our first two premises from earlier:

TRA P1: The flow of time must be expressible as a rate;

TRA P2: The flow of time must be expressible with the right sort of rate.

Building primarily on P2, the TRA makes the added claim that we must be able to ask how fast this rate is:

TRA P3: If anything flows, it is sensible to ask how fast it flows.

This leads to P4:

TRA P4: In order to determine 'how fast' something changes, we must posit a separate time scale.

We then reach the following conclusion:

TRA C1: If time flows, it requires a separate time scale.

Smart further argues that if we posit another time scale, that time scale must be like the first time scale: 'Just as we thought of the first time-dimension as a stream, so will we want to think of the second time-dimension as a stream also' (Smart 1949, 484). Some might object that, obviously, scales or dimensions do not flow. Smart seems to have set up this argument elicit just such a response: B-theorists, such as Smart, reject any temporal dynamism.

The TRA is an enthymeme. It requires the premise that this new time scale must be another dimension of extension, as covered with Smart's rivers of time argument (Smart 1949). We can thus reword the argument as follows, starting from P3 (there is nothing objectionable about the first premise):

TRA P3: If anything flows, it is sensible to ask how fast it flows.

In line with Smart's claim, **TRA P4** is modified to refer to a dimension of extension rather than a time scale:

TRA P4*: In order to determine 'how fast' something changes, we must posit a separate time-dimension of extension.

TRA C1*: If time flows, then it requires a separate time-dimension of extension.

In this chapter, I will dispute the soundness of this argument by demonstrating that one can consistently reject **TRA P4***. I am willing to accept C1 in the original, unmodified TRA argument, insofar as this just means there is another dimension of analysis. However, I reject **TRA C1*** by offering a counterexample to **TRA P4***. As I will argue shortly, money is impredicative. Hence, we can measure 'how fast' money changes without positing a separate time-dimension of extension.

Here is where Price's sensibleness objection has some purchase. In what way can such a second time scale be at all sensible in his sense? Oliver Pooley describes this as

the 'two times' argument. According to this argument, the flow of time is accounted for by ordinary, B-theoretic time, and 'supertime', which is A-theoretic. B-theoretic time consists of the permanent relations of before and after, while A-theoretic consists of dynamic or changing properties of events. Future events eventually 'become present' and then 'drift off into the past'. The now moves along the series of times from earlier to later times. This leads to another set of premises, which generate the regress in the TRA:

TRA P5: If a scale is a time scale, then it must flow.

TRA P6: In order to determine 'how fast' something flows, we must posit a time scale.

TRA C2: For any time scale (n) there must be posited another time scale (n+1)

This lays out the problem of Skow's 'supertime'. This 'supertime' must also flow. My summary of the TRA is a composite of the formulation given by Smart and that of his predecessor C. D. Broad. Broad lays out the TRA as follows:

> If anything moves, it must move with some determinate velocity. It will always be sensible to ask 'How fast does it move?' But since the series along which presentness is supposed to move is itself temporal, this question becomes: 'How great a lapse of time 1 does presentness traverse in a unit of time 2?' Again, a regress of time-dimensions is imminent If anything moves, it must move with some determinate velocity. It will always be sensible to ask, 'How fast does it move?' But since the series along which presentness is supposed to move is itself temporal, this question becomes: 'How great a lapse of time 1 does presentness traverse in a unit of time 2?' Again, a regress of time-dimensions is imminent. (Broad, C.D. 1938)

As mentioned earlier, Broad formulates this argument in order to conclude that time is not like motion in time but a change of time. Hence, the rate at which time flows will not be expressible as 'one thing relative to another'. But we must be careful here. Below, I will propose examples of how we analyse common units. Sometimes we treat different occurrences of unit terms as referring to distinct quantities, and other times as referring to the exact same quantity. Examples of such rates and associated units include 'one dollar per one dollar' and 'one second per one second'. The next chapter will cover the identity of units in greater detail.

At this stage, the moves that requires scrutiny are the presumptions both of a dimension of extension and that this dimension is temporal.[20] We should take note of the

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[20] It is uncontroversial to refer to the geometric structure of Euclidian space, often denoted by E^3, as three-dimensional. These dimensions of extension are ways of being extended. There is less consensus about

difference between 'time-dimension', as used by Broad, and 'time scale', as used by Smart. Smart slides from talking about a 'time scale' to talking about a 'time-dimension'. His initial claim concerns time scales. If we interpret this as referring to the kinds of dimensions we employ in the measurement practice, then this makes sense. However, the word 'dimension' has over time become synonymous with 'extension' in the literature on the flow of time. This ambiguity has led many to believe that the TRA is a devastating objection to the flow of time. We must concede that measurement involves comparison with something. One problem with the regress to further 'nonsensible' time-dimensions is that, as Smart correctly notes, what 'flow of time' refers to becomes systematically ambiguous with each additional time-dimension (Smart 1949, 484). However, ambiguity may not be such an important problem when we are talking only of 'time scales'. The examples I will raise in this chapter draw attention to cases where a quantity is compared to itself.

If any time-dimension flows, then for there to be an answer to the 'how fast' question, we must posit an infinite series of time-dimensions. The objection then claims that this series should be rejected, because it is ontologically explosive. Smart thinks the problem is even worse than that. When we talk of time flowing then we are stuck thinking of infinitely nested dimensional rivers. Each river offers its own answer to the question 'how fast?'. This makes the 'how fast' question systematically ambiguous. Based on this, Price thinks that talking about time flowing is hopelessly incoherent (Robinson Erhardt 2023). He is willing to entertain the idea that 'one dollar per one dollar' says something sensible, whereas 'one second per one second' does not. The difference is that in the case of money, exchange of a dollar for dollar represents two different things: the dollar you give me, and the dollar I give you (Price 2011b, 304; Robinson Erhardt 2023). According to Price, in the case of 'one second per second', 'the problem is not that these amounts of time are necessarily, a priori, of equal length. The problem is that they are the

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whether time is extended in the same way or whether the temporal dimension is more properly called duration rather than extension. This is quite unclear. John Locke, for instance, referred to duration as fleeting extension (Locke 1824, 170). In special relativity, time is bundled with E^3 to produce Minkowski spacetime. Maudlin believes that Minkowski spacetime vindicates the substantivalist view of space(Maudlin 1993, 202). Spacetime has its own existence and structure independently of matter, but it is not the sort of structure that can have an absolute metrical structure. In this sense, it is a dimension of extension. However, the view I am defending is that this way of extending is different than the three ways of extending in E^3.

very same thing' (Price 2011b, 304). This is what I will refer to throughout this thesis as the 'very same thing' argument.

Miller and Norton describe arguments like Price's as the No Rate Argument (NRA). Any self-referential explanation of time's flow cannot result in a rate, and so P1 cannot be true (Miller and Norton 2021). According to them, a rate requires that the quantity represented by the numerator position is distinct from the one that is represented by the denominator: 'A dollar per dollar is not a rate; a second per second is not a rate' (Miller and Norton 2021). They think that this violates the NRA, since what sits in the numerator position is not distinct from what sits in the denominator position. The idea is that when numerator and denominator refer to the same quantity, the units cancel out. What one is left with is not a rate, but a dimensionless quantity.

According to Price, the distinction between the dollar I give you and the dollar you give me is a reasonable one. This thesis will consider whether the same thing can be said about time. Typically, when we make a measurement based on a comparison to a gauge, we make a distinction between what is being measured, such as distance or a temporal interval, and the abstract unit of measurement which represents it, such as a metre or a second. Since Price acknowledges that the dollar I give you and the dollar you give me are two distinct things, the numerator is different than the denominator. This satisfies the measurement requirement given above.

Price is willing to countenance cases where units do not cancel out. This makes our analysis harder. Consider the following three examples of quantity ratios: 'one dollar per one dollar', 'one second per second', and π. The thought here is that 'one second per second' is more like π than like 'one dollar per one dollar', and hence dimensionless. One possible solution to this problem is a distinction proposed by Michael Raven:

> A rate's dimensions can be the same or can differ. Rates with the same dimensions are commonly called, *dimensionless*. (Similarly, rates with the same units are commonly called, unitless.) The common terminology misleadingly suggests that dimensionless rates lack dimensions. But this is confused. If a rate is dimensionless, then the dimensions are the same. So (here's the misleading part) a dimensionless rate has dimensions—the same dimensions. A dimensionless rate is a rate. To be dimensionless is not to be *adimensional*. (Raven 2011, 5)

The goal of this section was to establish a workable distinction between a rate and a dimensionless quantity such as π.[21] The distinction that Price gives is a good starting point. However, this means we need to do some work in distinguishing adimensionality and similar concepts from that of being dimensionless.

Here is one possible definition of a rate:

R1: All rates are ratios; a ratio is a rate *iff* the numerator and denominator represent distinct things even if they have the same units.

Under this definition, a dimensionless quantity may be a rate. The obvious example is Maudlin's example of 'one dollar per one dollar'. This is both a dimensionless quantity and a rate. But an adimensional number may not be a rate. R1 thus gives us an answer to question #1. I will later argue that in the case of money, R1 is not violated, and we may make an argument for something similar with respect to time.

2.3 Rates of Exchange

In this section I will explain why 'one second per second' is more like 'one dollar per dollar' then Price thinks. Tallant (2016, 41) gives a useful break down of rates. There are four distinct groups or contexts in which we generally ascribe rates. They are as follows.

R1 The first describes changes in processes or properties. A simple example is a rate of speed or even acceleration. In this context, rates denote changes in properties over some time or duration. One such example is kilometres per hour.

R2 Second, rates are used in an economic context. Examples from this group include tax rates, exchange rates, and interest rates (although contrary to Tallant, interest rates also resemble speed in tracking changes of properties over time).

R3 Third, rates describe statistical proportions. Examples from this category include rate of smoking or covid infections per thousand, or rates of obesity or of divorce.

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[21] It is worth pointing out that Maudlin thinks that even π retains the dimension of length. Similarly, π is defined as a ratio of a length (of the circumference of a Euclidean circle) to a length (of the diameter). The ratio is length to length; length does not 'cancel out' (Maudlin 2007, 113). Price on the other hand thinks that π is unitless. He goes as far as to say that 'we might just as well say that the ratio of the circumference of a circle to its diameter flows at π seconds per second (Price 1997, 13). Ironically this is exactly what Newton's kinematic and fluxional geometry does... these moving figures themselves trace out figures of a higher dimension by their continuous motion. 'If all mathematical quantities are so generated, every fluent will have a velocity or fluxion at every instant, and each may be regarded as "aggregated" out of its fluxions over time' (Arthur 1995, 342). Quite literally, then, π flows at one second per second.

Such rates can be used to determine economic rates such as insurance. Likewise, insurance rates over time are changes in properties over some time or duration.

R4 Fourth, and more controversially, rates are used for score keeping. An example here is a service approval rating. There might, however, be a good argument that this context does not differ much from that of proportion or financial rates (think for example of TV ratings) (Tallant 2016, 41).

The monetary claim that 'a dollar is worth a dollar' falls under R2: rates in an economic context. The purpose of introducing these distinctions is to try to answer question #2; why do claims about the flow or passage of time require a rate? When it comes to our use of money, if we say that a pound coin is worth a pound, we should ask whether we are comparing two physical objects: Are we comparing one individual coin to another very similar coin or are we, comparing that coin to some abstract thing, 'the pound'? This matters because 'the pound' seems to be an abstraction similar to 'the second'. I will show that the abstractions of 'the second' and 'the pound' are similar enough to undermine the TRA: given the similarity between money and time, we should expect a money equivalent to the TRA. With this in mind, I ask: what sort of rate does money require?

This resembles another question: What sort of rate does a temporal parameter, such as the motion of a clock, require? The exchange rate of 'one pound per pound' has the same form as 'one second per second'. If these two applications of 'rate' are similar enough, then we should be able to apply some conclusions derived from one context to the other *mutatis mutandis*.

With TRA, we do not have a regress of justification, but rather of the direct application of concepts like 'rate' or 'velocity' to time. This will help us answer question #4. Does such a rate get at some metaphysical property, is it solely a doxastic or epistemic description? What I am asking is whether saying 'time flows at a rate of one second per one second' is of heuristic value for acquiring many other true beliefs but does not pick out something in the world. In order to understand this problem, I will introduce the ice hockey example. The worry is that 'one second per one second' only says something about an ideal clock. My goal is to keep this rate firmly within our actual measurement practice and not appeal to an ideal clock.

In Chapter 5 we will examine the Embedded Perspective view (EPV), which claims that we cannot infer anything about the metaphysics of time from the nature of clocks (ideal or otherwise), since clocks merely tell us about something internal to our measurement practice. This is precisely what impredicativity can rebut.

The EPV strategy seeks to account for our experience of passage without making any metaphysical commitment to passage. I will examine this move in greater detail later, but for now it is worth considering Forbes's implacability argument. According to Forbes, time has an implacability that space does not. If anyone doubts this, they just have to remember a time in their life when, no matter their desire to procrastinate, an impending deadline relentlessly advanced ever closer. No one doubts this sort of experience of passage. Forbes argues that our experiences as of passage require some metaphysical treatment which, importantly, supports our knowledge that such passage will keep taking place (Forbes 2015, 189). This has implications for the money practice. (If you doubt this, then maybe you have not experienced the pressure of making loan payments on time.) The EPV response to Forbes' argument is that an account of our experience as of passage only requires epistemological and psychological features, not metaphysical ones (Callender 2017; Ismael 2023). The EPV tries to deflate the experience of passage, the so called "dynamic" features of time, by using psychology and cognitive science rather than ontology. Our experience of temporal flow is explained by things like memory, anticipation, the appearance of causal asymmetries and decision-theoretic structures. The decision-theoretic structures seem to go hand in hand with information gathering and utilisation. The question is whether the future is open or only our knowledge of the future is open. For now, we must set this aside until Chapter 5. There, I will continue the analogy with the money practice to suggest that we are committed to thinking that the openness of the future, in such practices as carrying out transactions, is not just a feature of our knowledge of the future.

At this stage we encounter a meaning regress problem. The general line of thought is that all other uses of the term 'flow' can be meaningfully considered to have a rate. The very justification of the claim that time flows must include a guarantee that rates are things we can measure. This tells us how we can warrant such a claim, and I am not backing away from it. However, Broad, as we saw earlier, thinks that the TRA undermines thinking of time's flow as a change *in* time but rather a change *of* time. In this way, it is not

like a motion. The typical description of time we get from those who do physics is that time is something measured by a clock (Arias 2005; Considine and Considine 1985; Park 1981; *Wikipedia* 2025, "Time in physics"; Zwart 1972).[22] This picture might tell us a lot about clocks, but it tells us very little about time. Clocks work because states of affairs such as the distribution of sand in an hourglass or hyperfine ground states of caesium-133 atoms change over time. This raises a further question: Is measurement the right kind of concept to include in fundamental physics? According to Maudlin, at least when it comes to relativity, there are no absolute velocities; if we ask how fast are we moving we find that this isn't a good question (Robinson Erhardt 2024), because spacetime structure just does not have what we need to be able to answer that question. In relativity, we are stuck with what Newton referred to as relative motion (Newton 1687, 78).

Fortunately for this thesis, we have a concrete example of this more nominalist view of time in the view of Isaac Barrow.[23] He thought that equable motions were chosen by convention. We compare motions with one another by the use of time as an intermediary (Barrow 2008, 37). This of course is eminently sensible. However, such an approach had rather odious consequences for Newton. For one, it would imply that there were not absolute, true motions of bodies with objective, discernible velocities that can be measured, because we could not frame an abstract notion of rest. One might ask at this juncture: so what? Newton was wrong. The interesting thing is that Newton's views on money followed this more nominalist form. We will return to this when we construct the money regress argument in Chapter 2.

In what follows, I will present examples of how we talk in terms of how fast without using what we would normally refer to as a clock. We measured time well before we had caesium clocks. Time was derived from the motions in everyday life. It is only with this great variety of motions, exhibiting variable rates, that we could even produce more and

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[22] The saying that time is something measured by a clock is often attributed to Einstein, but I have found no direct source to support this claim. In my opinion, this way of directly connecting time to the measurement of time further serves to reinforce the dimension of time. However, as Maudlin correctly points out, measurement is not the right sort of concept to *be at the bottom of physics*.

[23] Barrow's view of time can be described in nominalist terms. Measuring time constitutes a problem. Newton posited absolute time, and absolute time has an intrinsic metric. However, for our purposes, Barrow's example is antirealist with respect to the second as an intrinsic measure. According to Barrow, 'we cannot tell what their Quantity is, unless we measure them so Time likewise a quantity of it, we are obliged to call in motion to our assistance, as a measure whereby we may esteem and compare the Quantity of it; and thus Time as measurable signifies Motion' (Barrow 2008, 7).

more accurate clocks. Hence, it is only with the relative comparison of less regular motions to more regular motions that we can have a concept of regular equable motions. This leaves us with an old question: Does time play an essential role in rate talk? Is it just a comparison of any two changes, or are we comparing any change to what Markosian refers to as the 'pure passage of time' (Markosian 1993)?

Since Newton, it is common to think of units of time as distinct from the contents of those units of time. According to Newton, 'absolute, true, and mathematical time, of itself, and from its own nature flows equably without regard to anything external' (Newton 1687, 77). If 'one second per second' is merely a comparison of one change with another, then there's no problem. This is just like Price's dollar example: there is one second at one time and another second at another time. As he asks, in his example of the Hume highway, 'how many miles they will encounter per mile (Price 2011b, 304)?' But this implies that we are comparing successive miles and likewise successive seconds. They are not the 'very same thing'.

"Since," as Barrow claimed, "we judge the regularity of the celestial motions by the help of [these local and sensible motions]" (Barrow 2008, 37), it seems plausible that these motions are the sort of thing that can provide the equivalent 'since' for the defenders of flow argument. Since we measure the passage of time with what we establish as equable motions, motions measure time. Question #2 can on this view be easily answered simply by pointing at motions and changes, which then the rate of time's flow. For Newton, it was clear that the topological and metrical structure of absolute space and time lay at the bottom of physics.[24] The Barrovian view is that measurable rates do not supervene on absolute rates. This offers strong reasons to be suspicious of measurement laying at the bottom of physics.

There should be a gauge that can act as a measure for the concept of 'the flow of time' to be meaningful. This, again, is what Price thinks is incoherent – which is a strong claim. It entails that even if you believe in the 'pure passage of time' then, according to Price, Newton's proposal that the rate of the flow of time can be accurately measured should we find an equable motion wasn't just empirically wrong but logically

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[24] With the geometry of Newton's absolute space and time, there was no need to consider separately topological and metrical structures. However, a contemporary of Newton, Gottfried Leibniz, saw a need to consider position rather that magnitude as the more important consideration (Wells Forthcoming).

incoherent.[25] This measurement is not just a matter of finding an equable motion. Something more needs to be said. As James Van Cleve claims, for absolute time to do its job, 'time itself would have to have an absolute rate, and chunks of substantival space would have to have absolute sizes' (Van Cleve 2011, 155). I take this to mean that all rates supervene on absolute rates in some sense. According to Van Cleve, comparative rates of change or motion do supervene on absolute rates.[26] This leads to the rather puzzling claim that 'absolute rate is a rate not consisting in a ratio to the rate of anything else. That is true; but a rate is already a ratio, so an absolute rate, though not consisting in a ratio or comparison to any ratio, is still a ratio' (Van Cleve 2011, 156). From Price's point of view, this is not very satisfying.

Likewise, without this gauge of an equable motion, there should be no way to justify the claim that time flows, even though time seems to be measurable. Even if we cannot find a justification, we should have some idea of what that justification would look like. At the risk of oversimplification, the objection interprets the claim that time flows as saying that time flows 'in terms of' or 'in comparison to' some other gauge. This is precisely the point that Newton makes: absolute time flows without regard to anything external. If I've interpreted the positions taken by Broad, Forbes and Markosian correctly, this is the difference between time and motion. A change of (absolute) time occurs without regard to anything external, whereas a change in motion is comparative. Rates of the latter can then be determined. One interpretation of Newton's use of 'equable' is that each unit of time is indistinguishable.[27]

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[25] Some more recent authors have applied the TRA to Newton and concluded that Newton's proposal that time flows equably without relation to anything external demands a still further time in which this flow can take place. Ric Arthur claims that 'it [time] would require a further time in which this flow can take place' (Arthur 2019, 70). On a side note, Newton is often misconstrued as a determinist. It is worth remembering that Newton's view of God was not the conventional Christian view. God did not exist outside of time. For Newton God was sempiternal (that is, existing for infinite time). On this view, even God can't change the past. One might think that his view that time flows equably depended on a God's-eye perspective, but this certainly is not the case.

[26] Van Cleve thinks that 'the wish to secure absolute rates is apparently what motivated Newton's belief in substantival time (Van Cleve 2011, 155). It is obviously speculation to try to deduce Newton's motives, but he did leave a few hints. First, he thought it was demonstrated by experimental evidence such as the bucket experiment. Also Newton said 'I have posited only as many of the properties as are required for local motion' (Newton 1687). I think he posits absolute space and time in order to derive laws of motion.

[27] Newton's teacher, Isaac Barrow described equable motions as 'ones that are constantly equal and similar to themselves'(Čapek 1976, 207). Where Newton seems to differ from Barrow is that 'equable'

We can take this a step further. According to TRA, when we say 'time flows', this implies There is a function in a mathematical sense of time flowing. For example, the measure or dimension of speed must make reference to other ways of extending, namely length and duration. There is another, similar claim, which seems entirely separate from the issue of rate: this measure, as a dimension function, must be both unique and fundamental. Yet, as Maudlin notes, we should ask whether measurement is the right sort of concept to be at the bottom of physics.

This measure is a function because it correlates two distinct things – distance and duration, or length and time. As a unique and fundamental measure, we should consider this measure as a dimension of extension. This is an implicit premise in TRA. Since we need to postulate another time scale, we quickly gloss over the presumption that this needs to be a dimension of extension. We will parse this presumption in more detail later in this thesis. Suffice it to say at this juncture that in Chapter 6, we will both encounter multiple time scales and see that they are not as problematic as Smart contends.

Before we draw any conclusions from money and measurements of value, we need to figure out what is at stake. Long before the Maudlin/Price discourse, Newton puzzled over both the ontology of time and the ontology of money. Motion, like value, is a pre-metrical concept. Barrow expressed the Aristotelian tradition by claiming that '[t]ime implies motion to be measured' (Barrow 2008, 35). Motion seems to be the starting point for an analysis of time. This tells us something about what a rate of speed is supposed to do. If we talk about time itself as a motion, then as we've seen above, we appear to get into trouble. However, we do not seem to get into the same kind of trouble when we apply this reasoning to money. Newton said that "we value it [money] because with it we can purchase all sorts of commodities" (Shirras and Craig 1945, 231). Money is not grounded in a value that is more fundamental. The direction of fit runs in both directions. Rather than using money to measure the value of commodities, money itself that has its value measured by commodities. Money therefore presupposes exchangeable value in order to be measured.

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need not correspond with any sensible motion. In other words, absolute time need not correspond to any 'equable motion' (Newton 1687, 77).

Why is this important? Here we have two different ontological approaches. Figure 1 is a conceptual diagram borrowed from Callender and generated using ChatGPT, with subsequent author modifications. It is a good illustration of how money and time can be compared. There we see all kinds of comparable things. We can compare all kinds of motions, such as heart beats to the rotation of the Earth and the speed of some photon. Likewise, we can compare things we value, like coffee, shoes and a vintage Citroën 2CV car.

Figure 1: A new view of time? (Callender 2010, 63) (OpenAI 2026)

It is worth considering an approach that Callender proposed. According to him:

> Thus, some physicists argue that time is a common currency, making the world easier to describe but having no independent existence. Measuring processes in terms of time could be like using money (left) rather than barter transactions (right) to buy things. (Callender 2010, 63)

In my view, Callender illustrates the approach that Barrow proposed very well. We use both time and money as intermediaries. Again, it is worth remembering that my argument is to turn the tables here. After all, measurement in general has no independent existence either. Money seems to have real causal powers, insofar as you can use it to get trainers, coffee and a nice classic car.

Money, it seems, is valued by the things you can get for it. Time, on the other hand, is not merely the totality of all motions and changes. Borrowing Markosian's language, in Newton we find the view that there is a pure passage of time rather than a mere convention for comparing various changes. Still, what we were after was a notion of flow, or flux, which would capture what's supposed to be special about time (Price 2011b, 304).

2.4 What We Have So Far

At this point, it is worth recapping some of the key components of this thesis. At the top of the list is how rates got into the discourse of the flow of time. The main culprit is the Temporal Regress Argument. It is worth considering that, as far as I can tell, there was no criticism of Newton's view about equable flow of time along the lines of the TRA prior to the 20th century.[28] We covered the commitments of the TRA in our discussion of P1–P6. In the next chapter, we will make good use of these commitments in constructing a comparable money regress argument.

Another component of our analysis is where rates fit in. It will be useful to restate R1 here: All rates are ratios; a ratio is a rate *iff* the numerator and denominator represent distinct things even if they have the same units. Under this definition, a dimensionless quantity is a rate and an adimensional number is not a rate. (We will make use of this definition in Chapter 6.) The main assertion I am making here is that the rate 'one dollar per one dollar' is dimensionless. It is, however, anything but adimensional once we take the time value of money into account.

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[28] Regress arguments are not unique to the TRA. There are two ancient sources of very well-known regress arguments. In epistemology, there is Sextus Empiricus and the Agrippan trilemma. According to *the* Agrippan trilemma, we are forced to choose between either circular reason (coherentism), infinitely many reasons (infinitism), and ultimate reasons (atomism). The 'sui generis' response to the TRA, in my opinion, resembles the ultimate reason approach. My taking both instances of 'dollar' in 'one dollar per one dollar' to refer to the 'very same thing' resembles coherentism. Where the rate of flow of time differs from justification is that no one seems to be very enthusiastic about postulating an infinite series of non-sensible dimensions of time.

Another ancient set of regress arguments can be found with fragmented works of Zeno of Elea. Zeno proposed a series of paradoxes. One such paradox that has survived is Zeno's epicheirema paradox. This regress argument goes as follows. 'if everything that exists has a place, place too will have a place, and so on ad infinitum' (Aristotle 2014a, 209a23–25). In this thesis, what I argue is that the problem is not an infinite regress as such, but rather that the regress involved is a 'non-sensible' regress. I intend to show that money, and by analogy time, can avoid the 'non-sensible' objection.

Still another point we made above is that 'dimension' is often used confusedly and ambiguously. In using the word, are we talking about the fundamental extension of spacetime, or our measuring practice? This question leads us to an issue central to our measuring practice: the choice of reference frames. It is worth remembering that even Kant recognised that there was a need to establish a reference frame for the purpose of measurement. He writes, as quoted earlier, that '[w]e cannot represent the three dimensions of space at all without placing three lines perpendicular to each other at the same point' (Kant 1998, 154). What I have argued so far is that the origin of such a representation has a role in establishing the identity of the measurement units. I will further argue that currency units perform their measurement function in an analogous way. Whether we are talking about seconds, metres or dollars, at the origin of the coordinate system, what is represented is the *very same thing*. In the money example to be presented later, I will argue that we can think of currency units away from the origin of the representation as being 'one thing relative to another', but as we approach the origin, they become the 'very same thing'.

In the next three sections I will consider three examples which focus on different comparisons between time and money. These will then be used to answer the questions with which we began this chapter.

2.5 Ice Hockey

In this section I will examine a situation in which we compare two clocks. In such a case we make comparisons with one measurement of time in seconds with another measurement of time in seconds. This is what takes place during a typical ice hockey match. What I hope to show is a real-world example in which time passes at a rate comparable to itself. As I claimed earlier the passage of the game at certain times passes at a rate of 'one second per one second', and at other times it does not. This will help us analyse whether we are comparing the same thing to itself or instead comparing two different things. As Markosian suggested, it is a case of comparing one change (i.e. one clock) to another change (the game clock) rather than to the pure passage of time. The goal of this section is to determine the contexts in which a rate of 'one second per one second' is a statement about changes in time relative to something like the pure passage

of. The degree to which we abstract is correlated with treating our units of time, such as seconds, as fungible.

When I play a game of ice hockey, I treat it as an event with a duration. The game is divided up into minutes and seconds. A standard game consists of three periods, 20 minutes in length. The game has its own clock. According to the rules of the game, each arena is required to have an electronic game clock (*IIHF OFFICIAL RULEBOOK 2023/24* 2023, 23). What is not specifically mentioned but seems to be assumed is that there is some expected relationship between the game clock, and the units it measures, and our standard time and units. At one level of analysis, each second is treated the same as any other second.

However, within the game some seconds count and others do not. In stoppage time, once a whistle is blown the timekeeper is required to stop the progress of the game clock. The game progresses during such times at a rate of zero seconds per second. Even the seconds that do count vary in significance. The seconds just before the final whistle feel more important. They demand a greater level of urgency and attention.

The clock is scrutinised closely; during some games, time is even added back on to the clock.[29] It is as though some seconds counted when they should not have been counted and thus must be replaced. In this context we treat the replacing seconds as fungible with the wasted seconds. On the other hand, If the game is out of reach, the remaining seconds become as insignificant as the seconds that do not count. My teammates might yell at the referee to 'just run the clock'. What they are communicating is that they want the fewest number of seconds possible to pass, so that we can get to the pub earlier to mourn our loss. The spell of the game is broken, and we no longer take the game's clock seriously. We start shaking hands and we gather up our hockey sticks and leave the ice. Nominally, the game progresses to its conclusion at a rate of one second per second, but in another sense the game is already over.

There are some puzzles about this practice. For instance, the question 'what was the shortest period in hockey history?' is ambiguous. I might mean to include overtime periods that end with the next goal scored, or I might mean to include periods that end

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[29] '34.7. VERIFICATION OF TIME Any loss of time on the game or penalty clocks due to a false "face-off" must be replaced as appropriate. The Video Review Operations may be consulted to ensure the time is accurately replaced' (*IIHF OFFICIAL RULEBOOK 2023/24* 2023, 66).

under abnormal circumstances such as power failure or a brawl. However, if the question concerns normally played out regular time period, they all have the same length: 20 minutes. Still, the question 'what is the shortest?' is meaningful. In this case, the game clock is assumed to not correspond with a proper time's clock. The duration measured by the game clock should be much shorter than that measured by a proper time clock. All whistles stop the time for some duration which is not recorded as part of the game clock. Therefore, the shortest period would be a period that has the fewest and shortest stoppages from things like goals, penalties, goalie saves, and all the other things that would cause a referee to blow a whistle. Accordingly, the shortest period possible would be a period with no whistles. Still, there is a further ambiguity. If there was more than one game to do this, we might say that the shortest period would be a period with no whistles and a game clock that to some degree runs fast. But maybe there is not something wrong with the game clock at all but rather the relativistic effects of playing closer or away from the equator or being higher or lower in elevation.

What the above discussion highlights are two ways of measuring the seconds and minutes of the game. The first is duration. The idea here is that the seconds measured bear some resemblance to other seconds. According to Price, the rate of 'one second per one second' is supposed to measure the 'very same thing' (Price 2011b, 304). But as we encountered above, every second has a different significance, a different content. It is only the abstract measurement unit of the second that has this 'very same thing' relation.

It is therefore worth considering what a second is. A second, in terms of duration or interval, is a base unit according to the International System of units (SI).[30] This base unit for measuring time, according to the SI, relates to other units in a system of units in the following way.

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[30] According to the SI, the second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom (Thompson and Taylor 1995, 39). However, another fundamental unit, the metre, is no longer measured by its comparison it to something of with a physical length of a metre, like a metre stick. Instead, the standard metre is much more like how clocks used to work. Length is now defined in terms of what we take to be an equable motion: the speed of light. According to the SI, 'the metre is the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second'. In traditional clocks, a second was defined geometrically as a measure of plan angle such as seconds, minutes, and degrees. In the SI, length (in metres) and duration (in seconds) constitute base units. The SI system is made up of two groups: base units and derived units. However, metres appear to be derivable from motion and time. The problem then is that the units of speed and velocity are derived units.

The SI unit of time (actually time interval) is the second (s) and should be used in all technical calculations. When time relates to calendar cycles, the minute (min), hour (h), and day (d) might be necessary. (Taylor 1995, 23)

What is obviously absent from the list are periods in an ice hockey game. The standard duration of a period is 20 minutes of ice hockey time. Therefore, in all completed ice hockey periods (in normal time as opposed to over time), the duration of each period must be either greater to or equal to 20 minutes.

But this is not the only way in which we can compare a second to another second. What about the case of urgency?[31] If we recall, Price's distinction between 'one dollar per one dollar' and 'one second per second', is based on the following: 'The problem is not that these amounts of time are necessarily, a priori, of equal length. The problem is that they are the very same thing'. If there are other contexts of analysis, such as urgency, then there is at some level a difference in kind between the quantities represented in the numerator and denominator. At issue here is how much different units of time are fungible. This seems to depend on the target of analysis, and the context in which the second is being looked at.

So, what does this example tell us about rates? When the game is progressing without any stoppages, without any whistles, we expect a few things. First, the game time clock beats out one second per second, in sync with the clock we use to tell time in ordinary life. There is no stipulation in the laws of the game that the clocks need to be in sync with SI clocks. It is possible that the game clock might run faster or slower than our proper time clocks. The game time might even accelerate as the game progresses. If that is the case, I would imagine that the participants would like to be aware of this. More importantly, I would like to know that this is picking out a quantity and not just a number. This is a point that Bradford Skow makes about the durations of a pendulum's motion within an inaccurate clock. If I am going to make any claim about how accurate the clock is, it will be in terms of seconds per second:

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[31] There is a tendency to treat the units with which we measure time, such as seconds and hours and days, are entirely separate from the content of those units of time. In a measurement, duration often is not the most salient feature – for example in a game, as in the ice hockey example. Urgency seems to be a function of proximity to the end and a close score. Forbes makes a useful distinction between time as Kairos and Chronos. Chronos is about clock measurements. Kairos is about urgency and opportunity. If this is the case then it is reasonable to compare seconds as Kairos to seconds as Chronos. Please see *The Growing-Block View* (Forbes 2025, 94).

The rate [the pendulum of a clock] can be reported as n seconds per second (and here n need not be 1). It can also be reported just as n - provided we remember that n here names a value of a quantity (the same value no matter what unit we use to measure duration), not a number. (Skow 2012, 389)

Even in the case where the two clocks are measuring out the duration of a second in the same level of accuracy, the determination of accuracy depends on the clocks agreeing. Even with caesium clocks, there is a small discrepancy between the definition of a second and the realisation of a second through whatever instrument is used. In the case of these clocks, we can expect accuracy of one second in millions of years. Still, the units of time do not cancel out. If one caesium clock is acting as an ice hockey game clock, for instance, then there is the question about what we can say about the seconds that don't count and the seconds that are added back on. There will be a difference between the 20-minute period of one clock and the 20-minute period of the other clock, if at any time there has been any stoppage. Further, there is a question of synchronisation. Even if these two clocks are placed next to each other and started at the same time once there is a stoppage, each individual second in the game clock will correspond partially to one second of the nongame clock and another subsequent different second of the nongame clock. The only reason things that seem to bear the 'very same thing' relation to one another in fact *do* is that they pick out the same abstract measure as covered by the SI unit discussed earlier. This is further compounded should time be added back on to the clock. Can this be described by a rate that does not treat the units as something that simply cancel out? This seems doubtful.

The goal of this section is to account for fungible seconds. This fungibility seems to come in degrees. When we consider caesium clocks there seems to be an ideal abstract second to which these clocks approach. In a few million years we will be off by a second. In a purely chronometric analysis, it is practical to treat each second as maximally fungible. This way we can say that the caesium clock is accurate to one second in millions of years. What this suggests is that there is a difference between the abstract seconds and seconds as realised in a clock. The treatment of the two seconds, the one in the numerator position and the one in the denominator position, remain distinct.

In closing this section, I will return to R1: All rates are ratios; a ratio is a rate *iff* the numerator and denominator represent distinct things even if they have the same units.

When we consider different clocks and what they measure, the second in the rate's numerator position seems to remain distinct from the one in the denominator. If we take account of relativity this becomes even more apparent. Below is an argument proposed by Steven Savitt in an unpublished paper, as cited and retold by Ric Arthur:[32]

> As Brian Greene has expressed this, "clocks that move through space in different ways tick off time at different rates (because they divert different amounts of their motion through time into motion through space)" (Greene 2004, 234). If the path is that of a system (say, an observer, "Bob") remaining at rest in the inertial frame, however, the spatial component of the 4-velocity will be identically zero, yet the observer's path will still be traversed at the same rate, $|u|$. But now, as Savitt notes, "there is only one dimension left in which he can have this speed, the first or temporal dimension". Even an observer who is stationary in some frame of reference still traverses a world-line through spacetime at the same 4-velocity, $|u|$, and this is now c times the rate of passage of time, $dt/d\tau$. For such an observer, time flows at the rate of one second of coordinate time per second of proper time. (Arthur 2019, 134)

Without getting too much into the relativistic weeds, the distinction between proper time and coordinate time is doing important work. The convention is to designate the frame-dependent time relative to an external observer as 't'. This time is referred to as coordinate time. A clock, on the other hand, measures proper time, usually denoted by the Greek letter τ (tau). Proper time is invariant. This means it is specific to a single set of processes along a specific path in spacetime. This is often referred to as a worldline. If some kind of super luminal signalling is ever achievable, then we might have to reintroduce to our physical theory something similar to absolute time and preferred foliations. However, as things stand, we can make do without it. Putting that possibility aside, it is worth identifying this distinction between different sorts of time that is a consequence of Minkowski spacetime. In Savitt's example, the comparison is between two things that Newton would recognise as a sensible and external measure of duration (Newton 1687, 77). My point here is that the rate of passage of time, $dt/d\tau$, makes sense

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[32] Proper time is a concept introduced by Herman Minkowski. Proper time, which is invariant, is distinguished from coordinate time, which varies based on reference frames. Proper time is the time measured by a clock through a specific path through spacetime. So what does it mean to say that a path is invariant? Physicists might say something like τ (proper time metric) simply parametrises the length between two points along a worldline and hence invariant. The problem is that clocks, including caesium clocks, run forwards not backwards. If we think of the ice hockey game as a process or event along the same path as such a proper time clock, then the duration of such game can be accurately measured but it is only measured in one direction.

even without such an absolute time and a preferred foliation. Passage can be explained locally with this relation between coordinate time 't' and proper time 'τ'.

The main issue that bothers Price with the idea of a rate of 'one second per second' is the lack of sensibility and meaning. This, in my view, requires thinking that the concept of measurement sitting at the bottom of physics. Certainly, this was Newton's view when he postulated absolute space and time, but it is not necessary for Barrow's view. At this stage it is worth noting what can happen when we compare coordinate time and proper time: We can start thinking of them as precisely the same thing. This happens when we establish an inertial frame of reference. Later in this chapter, I will argue that in the case of money, we can make the same move. The money practice depends on an analogous 'zero-starting point'.

At this point, we have made some progress towards answering question #4. Would such a rate describe some metaphysical property or is such a rate just a doxastic or epistemic heuristic? My claim is that rates are about our measurement practices. While the flow of time is a metaphysical claim the rate of the flow of time is an epistemic one. Much of our measurement practice is based on convention.

At this point it is worth returning to Jonathan Tallant's No Alternative Possibility (NAP) argument covered in footnote 3. Tallant sets the NAP argument out as follows (Tallant 2016, 36):

1. If x passes, then the rate at which x passes could be different;

2. Time cannot pass at a rate other than 1s/s.

Therefore,

3. Time does not pass.

Here, I think we have a basis for reconciling the NAP with P1. An inertial frame of reference merges the abstract second represented by dt and $d\tau$. It is not a question of whether there is no alternative possibility. Rather, there is no alternative given a particular inertial frame of reference. Because we choose frames of references, this means that this is not a valid argument because time can't flow at a rate other than 1s/s and the rate of times passage can be different simply by changing the frame of reference. If we consider two different inertial frames of reference such as the ones described by Einstein's twin paradox thought experiment, we can see that in both cases, in each twin's frame of

reference, time passes at a rate of one second per second. There is no other alternative possibility, and yet there is also the possibility that the rate can be different.

This sounds paradoxical, but in the following chapters I will explain how these are not mutually exclusive. The reason why these two seemingly contradictory premises can be reconciled is found in the measurement practice itself. As I am claiming, and as Maudlin agrees, measurement just is not the right kind of concept to be sitting at the bottom of physics.

In Chapter 6 we will return to this argument. In the case of money, a dollar can only have an exchangeable value of one dollar, and yet we can sensibly say that the currency unit of the dollar can undergo inflation and be worth less. This is true even though the dollar must be exchangeable in all frames as the 'zero-starting points' rate of one dollar per dollar. We can construct a parallel argument with money:

P1 If currency x is exchangeable (or worth something), then the rate at which currency x can be exchanged could be different

P2. Currency x cannot be exchanged at a rate other than $1 per $1

Therefore,

P3. Currency x is not exchangeable (or worth anything).

In the case of money, we see an obvious problem in that exchange, as the measure of worth, requires some duration. In relativity we are faced with a problem. All physical laws must be the same in all inertial reference frames, and no inertial frame is privileged over another. Yet we must also make general claims about what happens when we accelerate things in spacetime. Imagine we have a caesium clock in an inertial frame of reference. It is often claimed that things can undergo length contraction and time dilation. Such a clock therefore will measure time in a particular path through spacetime. This is often referred to as the world line.

Since caesium clocks are the most accurate measuring devices we have, we can determine the proper time seconds of that particular path through spacetime with great accuracy. As a rough analogy, we can think of all clocks, including caesium clocks, like an odometer measuring a particular path through space time. All those seconds pass at a rate of one second per second. Moreover, and importantly, proper time measurements are invariant (Petkov 2006, 108). This is true even if such a caesium clock undergoes time dilation and length contraction. However, as Green correctly points out clocks that move

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through space in different ways tick off time at different rates (because they divert different amounts of their motion through time into motion through space). Yet the time measured by these clock passes necessarily at a rate of one second per second. The necessity of this serves our epistemic needs. It serves our measurement practice. However, this is not a good enough reason to think that measurement is the right kind of concept to be sitting at the bottom of physics.

Here it is important to distinguish carefully between the metaphysical and the epistemic. We can talk about time flowing in a metaphysical sense, without reference to anything external, as per Newton. This is the pure passage of time, in Markosian's language. This vindicates the no-raters, but at the same time (as per Markosian) passage or flow may be measured with respect to itself. We can therefore derive rates of time's flow simply by looking at the effects of this flow – namely, motions and changes. Thus, we have an answer to question #5: Can there be flux or dynamism but no rate of this flux? This is where the comparison to money will be helpful. I will return to the NAP in Chapter 5 once we start talking about dynamism.

2.6 Sirloin Steaks

In this section I will introduce exchange and exchangeable value into our analysis. What I intend to illustrate are some curious aspects of our measurement practice. As we have already covered, measurement units are abstract. It is at this level of analysis that we can say that in 'one second per one second', these 'seconds' bear the 'very same thing' relation to one another. When I walk into my local butcher shop and reach into my pocket to pay for a sirloin steak, I typically have a choice. I can, *inter alia,* ask to use a machine and pay with my bank card, pay with the loose coins I have in my pocket, or pull out a large bank note and pay that way. Ostensibly, I am acquiring the steak the same way with the same kind of thing: I am buying it with money. I am using a particular kind of money, a unit of a particular currency, pounds sterling. The price of that steak is determined by a ratio. But we typically do not consider this ratio as a dimensionless quantity. Why is this? Possibly because the price of steaks is apt to change from day to day. Moreover, if we go into another shop the rate will be different.

The price, in this example, is an expression of units of the weight of a type of cut to units of currency. Underlying this ratio is the assumption that the two quantities,

kilograms of meat and quantities of money in pounds, are treated as fungible. It does not matter which particular steak we are talking about, and it does not matter which individual pound we are talking about. If I desire more weight of sirloin steak, then the ratio tells us the quantity of money that I am required to pay. I can choose the larger, thicker steak or I can even ask the butcher to cut a thicker steak for me. The price as a ratio does not vary based on the size of the steaks that are being sold.

Can we think of the price, as expressed as pounds sterling to kilogram, as a dimensionless quantity at some reasonable level of analysis? I think the answer is yes. Again, the sirloin steaks all have the ratio to pounds sterling. Every steak's price can be determined by taking a measurement of weight and multiplying it by the fixed ratio. Since this ratio is fixed, one could also calibrate the scale directly to measure weight in terms of pounds sterling. Instead of using units like kilograms we can simply replace those units with pound's worth of steak. If we were to do this, we would find that we have reduced the analysis to one single dimension, one single scale. Of course, if my butcher priced things this way I would be rather annoyed, because I have a particular point of view about what is relevant in this exchange. This relates to my goals and motivations, which are determined by what I take to be important 'Calculations in some system of measurement demand more time and trouble than we can afford' (Wittgenstein 2009, 159).

On the other hand, it is not too difficult to imagine another customer who just wants to buy according to the fixed some of money they have in their pocket. The convention of using kilograms as a unit of weight over using a currency as a unit of weight is advantageous for me simply because of what I find relevant. This is hardly the basis of any objective standard. There is, however, precedence for the fixed-money-in-your-pocket view. When commodities such as gold and silver are used in order to value, the worth of any quantity of gold and silver was based on weight, and this was applied to all other commodities. It is not too difficult to imagine all kinds of other commodities' weights being expressed in terms their weight in steak.

Still, in this example, the ratio of exchangeable value in terms of pounds to the weight of steak expressed in pounds would be one-to-one. Even though this is dimensionless, it would be hard to ignore the two different types of things being expressed by one unit, the price of steak. The price of steak expresses both weight and exchangeable value.

Can this same principle be applied to other phenomena, particularly when it comes to a motion? I think it can. Consider the example of the speed of light as described by Bernard Schutz:

> Since the speed of light c is so fundamental, we shall from now on adopt a new system of units for measurements in which c simply has the value 1! It is perfectly reasonable when driving a car or shopping for food to be content with the SI units: m, s, kg. But it seems silly in SR to use units in which the fundamental constant c has the ridiculous value 3×10^8. The SI units evolved historically. Meters and seconds are not fundamental; they are simply convenient for human use. We shall now take advantage of the universality of the speed of light to adopt a new unit for time, the meter. One meter of time is the time it takes light to travel one meter. The speed of light in these units is:
>
> $$c = \frac{\text{distance light travels in any given time interval}}{\text{the given time interval}}$$
>
> $$c = \frac{1 \text{ m}}{\text{the time it takes light to travel one meter}}$$
>
> $$c = \frac{1\text{m}}{1\text{m}} = 1$$

So if we consistently measure time in meters, then c is not merely 1, it is also dimensionless! (Schutz 2022, 4)

The basic move that Schutz makes is not much different than the one I make when using pound sterling as a fundamental measure of weight. Of course, there are practical reason why we differentiate our money practice from the units we use to measure weight. One practical reason is that the pound is much more fungible than any particular steak. The degree to which we think of all kinds of things expressed in all kinds of units as fungible is at the heart of our measuring practice. Another reason is that, in the past, it was convenient to express prices in terms of the weight of a particular metal such as gold and silver. A vestige of this remains in the name of the currency I used in this example, the pound sterling. When I consider other cuts of beef, the ratio itself changes. Not all the parts of the cow are fungible. Likewise, when I consider the price of sirloin over time, that ratio changes. Prices are apt to change over time and therefore there is a further dimension that can be analysed. This is true even if the price ratio remains constant. In Chapter 4 I will discuss further why currency tokens move towards maximal fungibility.

A further level of analysis can be applied if we account for inflation and deflation. Economics makes a distinction between nominal prices and real prices (Shafir et al. 1997). The idea is that what we take to be the more fixed reliable measurement of value, money, is itself apt to change over time. In inflationary times, the real price declines while the nominal price remains the same. Today a price might seem expensive and yet a year from now the same ratio might be a bargain. The real price has declined. When it comes to seconds, we do not have access to anything like what has happened to the pound. A second a year ago is considered to be the same 'length' in duration terms as today simply because the processes that define it. For example, 'the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium-133 atom' is the measurement we use for both. To say that a second a year ago is longer than one today is to say that the process involved in the caesium atom took longer, but what is absent is any meaningful way to measure this sort of time dilation. A year ago, a second was 'the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium-133 atom', just as it is today and will be tomorrow.

So far, in both the ice hockey and butcher examples, there are ratios that can be described as dimensionless quantities. The most obvious of these is of course 'one second per second'. However, when we treat the pound in its most fungible sense, the obvious conclusion is that it is exchangeable at a rate of a pound per pound. These examples raise another puzzle. The clock we normally pay attention to, the one that tells us our time relative to Greenwich Mean Time (GMT), is the one we take as being more fundamental.

One problem is that our planet and solar system constitutes a good clock. We can derive regular days, months, and years by the motions of our planet as it rotates and orbits the sun. Similar to what Barrow suggested, we judge the regularity of the celestial motions with the help of caesium clocks. The problem is that when we make this comparison, we find out that the earth and solar system clock is significantly less accurate than the caesium clock.

The Earth and solar system clock is far more important for our daily lives. We still live with the days, the seasons, and the years. This means our actual time-keeping practice is very much like the hockey game example. Time is added on to the clock and

subtracted from the clock when appropriate. By convention, our standard time practice involves adjusting the accurate caesium clock to be in sync with the less accurate earth and solar system clock, not the other way around. Therefore, even our GMT clock is conventional.

At this point is worth examining an example proposed by Wittgenstein. He asks what 'if our footrules were made of very soft rubber instead of wood and steel (Wittgenstein et al. 2001, 38)?' A reasonable reply would be to say that our measurements wouldn't be accurate. But this merely means that the measurement that we get will not correspond with the usual way of measuring. The important question that Wittgenstein asks is 'what if the elastic ruler fulfils some practical purposes' (Wittgenstein et al. 2001, 38)? It seems to me that the earth and solar system clock fulfils just such a practical purpose.

If I were to say the game went longer than expected, this statement will be relative to the GMT clock. Within the game all the seconds that counted will add up to the right number of minutes and right number of periods for the game. The puzzle is this order of precedence. Both Newton and Barrow believed that an equable motion was at the top of this order of precedence. Where Barrow and Newton differed was what constituted an equable motion. Barrow believed that supposedly the ultimate clock, the most fundamental clock, will be the most accurate. This might be the motion of the stars, for instance. However, with Barrow, the designation of an equable motion was done by convention.

Likewise, there is a level of precedence, an order of importance, that pound sterling has that the steak does not. This is purely conventional. That is why we need to make the distinction between weight and exchangeable value. In exchange, the value of the steak is measured by its worth in pounds, and not the other way around. I bring money with me to buy a steak at the butchers. The butcher does not take the steak to the bank to acquire money. We accept the pound as the more accurate of the two. So, why is this important? I use 'accurate' for a reason. While we do think of money as the more useful measure of exchangeable value, it is worth remembering that steak, like all other commodities that one might acquire, is also valued in terms of money. Because of this, money is chosen as a measurement for very similar reasons as equable motion is chosen for measuring time. In economics, money is not any more fundamental than all other

commodities. Therefore, there is no reason to believe that measurement lies at the bottom of economics.

In the Barrovian context, accuracy is simply correspondence to the equable motion chosen for keeping time. Of course, that correspondence is 'one second per one second'. Returning to one of the TRAs, it seems reasonable at this stage to challenge P4' In order to determine 'how fast' we must posit a separate time scale. There is no reason to presume that this scale need resemble anything like a fundamental dimension of extension. Nor does that scale need to itself flow. Money circulates in an economy, but sirloin steaks do not. In Chapter 3 we will return to the Barrovian model. We will consider inflation and ask whether the same concept can be applied to time and times relation to irregular motions.

2.7 The Fastest Century

My third example is like the first one. If you ask the average cricket fan to name the player with the fastest century in test cricket, they might not know the player's name, but very few of those fans will think in terms of batting a century against a standard clock. Instead, the evaluation of fastest is a comparison between runs batted and balls bowled. This is not to say that cricket is not played with a clock. Afterall, days have a certain length, and our quotidian clocks govern our lives outside of the game. According to the rules of cricket, there are mandatory breaks between various intervals such as innings, meals, drinks, and of course days. Still, like in ice hockey, there is an internal clock used as part of the score-keeping structure of the game. The basic measure of duration in cricket are legitimate deliveries bowled towards a batsman.[33] Like minutes and hours, balls bowled is part of a system of measurements that relates ball bowls to longer intervals such as overs. This can even be applied to the requirement that a day's play exceeds 90 overs.

It is worth revisiting Wittgenstein's ruler example discussed earlier. Here, instead of a ruler as our measurement gauge, we use clocks. We can imagine a 'stretchy clock-ruler' that adaptively stretches or contracts based on what is happening in the game. In

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[33] The term batsman is now an anachronism. The Marylebone Cricket Club (MCC) in London, the body that upholds the laws of cricket, have officially introduced a change in cricket terminology. Effective immediately, according to a statement published by the MCC on Wednesday, the term 'batsman' and/or 'batsmen' will officially be replaced by the gender-neutral term 'batter'(Judge 2021).

this example, we are measuring time or duration just like any other clock. What the participants in the cricket game are doing is comparing one measure of duration in terms of legal balls bowled with the occurrence of runs batted. The clock-ruler stretches or contracts depending on whether the batter is facing a spin bowler or a fast bowler, and it is adjusted for breaks in the game such as tea or the end of the day.

Again, it is worth asking whether this quirk has anything to do with time. I think it does, in ways similar to money. Perhaps one can say that the cricket example is not about measurement at all, and that the participants in the cricket game should be admonished for measuring time wrongly. Then again, the practice of adjusting our caesium clock time pieces to corresponded to the 'stretchy clock-ruler' of the earth's rotation and the earth's orbit around the sun are equally worthy of the same admonishment.

On the other hand, if we return to the TRA, then when we say a cricketer has achieved the fastest century, we are making a claim about speed in some sense of the word. If we are speaking of 'fastest', then there must be a sensible way of talking about degrees of 'fastness'. It should be expressible as a rate. This is not unlike our first premise:

P1 If anything flows, it is sensible to ask how fast it flows.

Likewise, recall P2:

P2 In order to determine 'how fast' something flows, we must posit a time scale.

In our day-to-day practice, we simply get out a clock. Not so in cricket. The time scale in cricket is balls bowled. Balls bowled in cricket is an equable motion for the purposes of cricket. If we look to Barrow for guidance, then we get this way of looking at the situation:

> I reply that that, if the sun-dial is found to agree with motions of any kind of time-measuring instrument, designed to be moved uniformly by successive repetitions of its own peculiar motion, under suitable conditions, for whole periods or for proportional parts of them; then it is right to say that it registers an equable motion. (Barrow 2008, 37)

The peculiar motion of bowling, along with its orderly repetition, suggest that it can be used as a means of registering an equable motion. Since Newton, however, the idea has been that when we consider a rate for the flow of time, that 'flows equably without reference to anything external' (Newton 1687, 77). This is not the way Barrow considered it. Obviously, we have better candidates for serving as this equable motion. The most obvious, and the one that seems the most accurate, is a caesium clock. For the sake of

this example, and from the point of view of the cricket match, the passage of the cricket match, and the question of the fastest century, a caesium clock does not help. Still, according to the TRA what is demanded is C1:

C1 If a cricket match passes (flows) then it requires a separate time scale.

In the case of a cricket match, there is a separate time scale. It is our usual quotidian clocks and their measurement of time. These measures of the passage of time are convenient. However, it worth asking whether the rate depends on the existence of another time scale. The cricket match passes by at the rate of one legal delivered bowl per one legal delivered bowl, and hence an over is 6 legal delivered bowls per over. In this sense, the rate in which a cricket match passes does not supervene on absolute rates.

At issue here is the question of whether this fact of the game depends on what we take as time and clocks in our daily, normal sense of the word. What this example suggests is that it is perfectly reasonable to say, without reference to anything external, that cricket matches pass at the rate of one legal delivered bowl per legal delivered bowl, and that because of this we can decide that the fastest century batted is the century with the least legal delivered balls bowled.

2.8 Ice Hockey, Steaks and Cricket

We are now able to answer the five questions that we started the chapter with.

1. **What is a rate?** R1: All rates are ratios; a ratio is a rate *iff* the numerator and denominator represent distinct things even if they have the same units.

2. **Why does the claim about flow or passage require a rate?** It does, but not in the way Broad, Smart and Price think. Claims about flow and passage are claims about changes of a state at one time compared to another. Rates do not supervene on absolute rates. We must first establish a reference frame to answer this question. Rates can be found in motions and changes that time measures. In the next chapter we will explore in more detail how money demonstrates this by constructing a monetary regress argument (MRA).

3. **What is the right sort of rate required to manifest flux or dynamism?** We can now say what it should not be: It should not be another temporal dimension of extension. The right sort of rate involves comparison to motions and changes. We will have to wait until Chapter 6 to answer this question more rigorously.

4. **Would such a rate describe some metaphysical property or is such a rate a doxastic or epistemic description?** That time flows is both a metaphysical and epistemic claim. However, rates are influenced by our epistemic needs. Rates can justify our beliefs about time flow, but they say very little about the metaphysics of time's flow, simply because measurement itself is the wrong sort of concept to be at the bottom of physics.

5. **Can there be flux or dynamism but no rate of this flux?** Yes, but only in the context of metaphysical claims about the flow of time. Measurement just is not the right sort of concept to be sitting at the bottom of physics. There is no sensible rate of time's movement through time. It is as Barrow described. If we take the Barrovian approach seriously then Time, in its absolute and intrinsic nature flows perpetually with an even Tenor (Barrow 1735). This is congruent with the *sui generis* claims of Broad and Forbes. We can make epistemic claims justified through measurement of the rate of time's flow relativised to a reference frame.

To return to the butcher shop example for a moment, both the butcher and I agree there is a system of prices that constitutes a rate of exchange. The sausages have one price per kilogram, the sirloin has a different price, and the brisket another. These all have commonalities that both of us take advantage of: a system of measurements for weight (expressible in this case in kilograms) and is a monetary system that can express (even if perhaps crudely) exchangeable value. The products that the butcher has on sale change frequently, assuming that is that the butcher is successful. There might be a special on brisket one day and one on sausages the next. But the sirloin steak, for example, is not the standard that measures exchangeable value. Instead, we use money, which is considered the more fixed and reliable measurement. This again raises a puzzle. Every day all the prices in the butcher shop are in flux: each day the pound in my pocket can buy different amounts of the things I want. If this is so, which is each of us treating as the most fixed and certain thing?

This price fluctuation is not limited to the butcher shop. The prices of all commodities fluctuate constantly. The means of exchange, money, must therefore also be in flux, as most people are aware. The 70s and 80s were rife with inflation, while the three decades after saw its gradual decline (Ha et al. 2019). After the aggressive quantitative easing seen in most developed countries in the wake of the COVID pandemic, inflation returned. If prices as expressed in pounds sterling rise, this is

equivalent to the pound dropping in value. In the butcher shop example, we saw how we could simply use the pound sterling as the measure of weight. We also saw that trying to rely on something fixed and unchanging in value, such as gold and silver, is problematic: these aren't very good at staying fixed and unchanged, even though the measure of this flux can be hard to detect. As Fisher observes:

> There is probably no defect in the world's economic organisation today more serious than the fact that we use as our unit of value, not a thing with a fixed value, but a fixed weight of gold with a widely varying value. (Fisher 2014)

If I continue to think that the pound in my pocket is still worth the same, this is quite odd. It is worth one pound per one pound, and this quantity cannot be anything different. If people value money, as Newton claimed, because of what they can get with it, then when a currency undergoes inflation there should be a comparable drop in how they value that currency. This drop must have a price or a rate, but it can be difficult to understand which thing undergoes the change measured by that rate. For example, it seems perfectly possible to make sense of the dollar being worth a smaller amount of pounds sterling today than yesterday: this means the dollar dropped against the pound. But is this change in exchange rate an expression of the pound rising or the dollar dropping? Similarly, when I am in the butcher shop and sausages are more expensive, is it the value of the pound that is changing, or the price of sausages? It is not clear that there is a fact of the matter. This is similar to how we treat measurements involving time. For example, velocity is a frame-dependent concept, which suggests that the concept of velocity does not represent something objective (Petkov 2008, 177).

Money measures value in the same way clocks measure out time and metre sticks measure out metres. We understand that it varies in value, but we still treat its value as constant; we treat £1.00 as being worth £1.00. But what does this actually mean? Does each instance of '£1.00' denote the same thing, or does each denote a different one? The greater the fungibility we treat currency units as having, the more this practice resembles how we think of time being, as Price describes, 'the very same thing'. We will return to this point in Chapter 4.

If I use a metre stick as a gauge, then I am making a particular type of measurement. I am determining length. How do I determine the values of length? Just so: for example, if one stick is twice the size of a second stick, I can determine the ratio of the

first to the second one and derive the number 2. In order to set up what Bradford Skow called a 'faithful' scale, we must assign units. For example, we can call the length of the first stick a 'metre'. That done, we can determine via a ratio the standard gauge quantity of one stick, the metre stick, and whatever length that I am measuring:

> So a determinable property is a quantity if and only if for any two values of that determinable there is a number that is the ratio of the first value to the second, and these ratios structure the values so that their structure is relevantly like the structure of the positive real numbers. (Skow 2012, 3)

The reason why we can use gauges of any sort is that we can assign units to magnitudes. The ratios of these units of measure then correspond to the positive real numbers: a certain length is one metre long, each pound note is worth £1.00 and time interval of a particular length lasts one second. More importantly, these values can be represented along a number line, or a dimensional axis. Taking this into account, it is not too difficult to see how we spatialise our units of time. The units – whether seconds, minutes, hours, days or years – extend along the positive real number line in the same way in which length does.

This leaves us with a problem. When I combine units of length and units of time by representing them on intersecting axes, I can derive another axis of analysis: speed. This dimension of speed can be analysed in the same way as length and time, and is often plotted as its own axis. We even have a definition of a unit of length in terms of speed over time (SI definition of the metre). Even though this is the case, speed is not a dimension of extension, like length and time. We can however analysis it as though speed did extend by assigning an axis for that purpose.

Things are narrower with time. The take-away from the Ice Hockey example is that we often do compare one clock to another. The accuracy of the caesium cock makes it an excellent stand in for an ideal clock. Perhaps when we say that a caesium clock has a certain degree of accuracy, we are apt to compare it to an ideal clock that is perfectly accurate, but it might also merely indicate the divergence among relevantly similar caesium clocks. One question the TRA leads us to is: what is needed to obtain a comparable dimension of speed axis? There are two different ways to do this. First, we could have one caesium compared with one or multiple distinct caesium clocks. Second, we could compare the caesium clock to an ideal clock.

As per my butcher shop example, such a representation is doable in the same way that a sirloin steak can price money. Still, there is a problem with the representation itself. If we recall, my main target for this thesis are views that deny that time flows as a result of some sort of conceptual incoherence. There is still the more difficult task of refuting deflationist metaphysics of time. This deflationist view holds that metaphysics should add nothing beyond what fundamental physics already posits. The long and short of this is that we still need to ask where is the dynamism? There needs to be an account of the way we conceive of enduring or extending. Flow has a strong suggestion of directionality. Baptiste Le Bihan gives a good account of how the various realist views on time are nested. (Bihan 2015). The basic idea is that those who defend the realism of time flow are realists about time's direction, those who are realists about time's direction are also realist about time as a dimension of extension. Some anti-realists about time, such as Julian Barbour, for instance, reject all three properties (Barbour 2001). In Chapter 5, we will examine how the embedded perspective view (EPV) is amenable to whatever levels of time anti-realism that are entertained by physics. However, their main goal is to naturalise the A v B debate. This, I believe constitutes enough of a distinction between the EPV and strongly timeless theories of Parmenides, Barbour and Tegmark.

With this in mind, we cannot help but think of duration in spatial terms. It is much easier to think of extending rather than enduring. It is for this reason that even as far back as Aristotle time is represented as a line. Barrow goes as far as to say that time has many analogies to a line. The danger is that representational convenience could be baked into our ontology. Flow is not change simpliciter. Likewise, if a second per second is going to make any sense, it cannot just be saying something about speed. Again, flow says something about direction. It cannot therefore be merely a scalar variable. If time extends, it does it in a way that is distinguished from space and this distinction we can describe as duration, things that persist intime endure as opposed to spatially extending. One move that we might consider is to postulate that time has a one direction property. With that we can think of time as a vector. The flow of time would therefore be a velocity, but this is still misleading. This might make the representation easier, like thinking of flowing down a river but this merely spatialises that which we are trying to say is not spatial. Money can help us realise a dynamic image of time.

In the next chapter, I present, in more detail, the ways in which money is treated conventionally. This can be applied to time. What we will continue to see in this thesis is that measurement just is not the right kind of concept to be sitting at the bottom of economics nor physics even though they are indispensable in the analysis. In this chapter I have hinted at a response we can expect some opponents to the flow of time can make. The money argument that I have presented here and will go into in more detail with the construction of the MRA is about our practice. I have claimed that the now or present has a substantive epistemic status. It is expected therefore that the distinction between epistemic goals can diverge from the metaphysics. The main claim is that temporally embedded perspective like our selves will invariably and perhaps necessarily make use of manifest time properties such as the experience of the present and time flowing and money simply reflects these practical biases. The epistemic claim is that we can make sense of the role played by a unique present in concepts like cause and effect without accepting the metaphysical substantivity of the present. The argument concerning the distinction between 'epistemic openness' and 'ontological openness' will be addressed in Chapter 5 when we examine in greater detail the EPV. Suffice it to say at this juncture, I am defending Forbes's account of the knowledge asymmetry, if we were to give an account of everything that exists, that account would change over time(Forbes 2015, 188). It is this kind of change that gives an account of the flow of time. If what I am claiming is correct then there isn't a neat division between what exists, as in the ontology of everything, and the epistemic goal of science of giving an account of everything. In Chapter 5, I will argue that this is the result of the processes of information gathering and utilisation.

Chapter 3: The Monetary Regress Argument

3.0 Introduction

The goal of this chapter is to construct a regress argument for money - the Monetary Regress Argument (MRA) – that is similar in form and function to the Temporal Regress Argument (TRA) which we covered in the previous chapter. The main objection to the TRA that Price highlights is that the relevant infinite regress postulates 'non-sensible' dimensions. What I intend to demonstrate is that the MRA satisfies the formal structure examined in the previous chapter. However, if the MRA does satisfy this formal structure then our money practice faces the same objection directed at the flow of time: money must regress to a 'non-sensible' dimension of analysis. Part of the goal of this thesis, recall, is to show that both Maudlin and Price, in setting up the analogy between time and money, have gotten the nature of money wrong. I will argue for a view that places money within our measuring practice. Money is an abstract measure of value, as implied by expressions such as 'unit of account' or as John Maynard Keynes puts it, 'money of account' (Keynes 2018a, 48).[34] Like other units of measure such as seconds or metres, dollars have the quality of being what Price calls the 'very same thing'. This is a relation of identity.

Still, it is worth remembering that, according to Price, it is sensible to ask, 'at what rate does it flow?' if time does indeed flow. In the case of TRA, there are two main hurdles. The first is whether a rate of flow is 'sensible'. The other is whether any such sensible rate can capture the dynamism which the flow or passage of time necessarily involves. In order to construct an analogous money argument successfully, I will need to propose analogous premises that can be substituted into the formal structure. Before we can get to the two hurdles mentioned above, then, we need to see how successful and how similar a MRA might be.

I will argue in this chapter that the relevant monetary analogue for the flow of time and the rate of flow of time is the simple notion that any unit of money is worth something.

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[34] Keynes lays out the measurement function of money as follows: 'The money of account—with which we began chapter I—was devised long ago in order to satisfy the need for a term in which to express general purchasing power. A definite measure of purchasing power by means of index numbers of prices is, however, a conception of modern times...where the conception of purchasing power and the measures of the changing purchasing power of money are first treated after the modern manner' (Keynes 1950, 55).

For, if it is worth something, then it must be worth something in terms of something else.[35] Deciding what economic value some particular thing has is usually done by asking 'for what it can be exchanged?' Exchange value and the rate of exchange value will therefore be treated as analogous to the flow of time and the rate of flow of time. If something flows, it flows at a rate. If it is worth something, then it can be exchanged at a rate.

In this initial analysis that we are immediately faced with a disanalogy between money and time.[36] When we talk about the value of money in terms of exchange, we see that such an idea involves modal considerations, as implied by the word 'can'. This is illustrated by the fact that, as we covered in the previous chapter and as Forbes claims, there is an implacability to time's passage (Forbes 2015, 187), an inevitable certainty that the future will arrive regardless of our attitudes towards it.

Some work will therefore need to be done to square this modal structure of money with the structure of time. In Chapter 4, I will need to give an account of money, in both the sense of as a human universal, money as in the individual currencies, and physical objects that we take to be money. These distinctions will play a significant role in this thesis. These distinctions create a puzzle. Some physical artefacts that we recognise as money will never be exchanged. What is of most interest for our purposes is abstract measurements of money as made by individual currency units. This is because we are comparing measurements of time (such as the abstract second) with their monetary analogues (such as the dollar). With money, measurement is made through exchange. I therefore must give an account of money that is never exchanged. The examples that I introduce are intended do just that.

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[35] Value claims carry with them their own set of philosophical problems. There are many things that we value that are not exchangeable. In the case of our money practice 'agent-relative value' is presupposed. Something's having a price implies that there is a measure according to which one economic agent is willing to give up something of value for that price and another is willing to acquire that valued thing for that price. What is appropriately exchangeable and what is not is a question in value theory, and is thus beyond the scope of this thesis. What is of concern here is that, in a system of prices and exchange, there is an equipoise between buyer and seller: the price of the exchanged object. There is thus good reason to think there is exchangeable value, simply based on our exchange practices.

[36] When we constructed the TRA in the previous chapter, we left aside modal considerations about the future. But now, for the sake of constructing the MRA, I have highlighted the modal component of money as distinct from time. My view is that time, as Barrow argued, "denotes not an actual existence, but a certain capacity or possibility for a continuity of existence" (Barrow 2008, 35). What the money example will demonstrate is this capacity of possibility stretches into the future. The money practice depends more on the expectation of a future, and this requires there to be future possibilities rather than past records.

We will return to money's modal implications, particularly the way money picks out a privileged present or 'now', in Chapter 6. There, I will give an account of the dynamism of time as presupposed and made manifest by our money practice. As we will see, the implacability of time's passage and our monetary discounting practice nicely dovetail. But this will have to wait for now. What we want to pay attention to at the moment is the measurement practice of money: it measures when it is exchanged. These measurements are ephemeral. Once an exchange has happened – once it is in the past – it no longer represents a possibility. Yet these measurements are the basis for our expectations about what future exchanges are possible.

Measuring speed involves comparing some spatial measurement (such as the spatial distance some object has travelled) with some durational measurement, typically made using a clock. We measure exchangeable economic value similarly through systems of prices. In this way, price is like speed. We determine an object's price by means of the relation between some quantity of some goods, such as units of weight of a type of cut of beef, and some units of currency. This relation is then expressed as a ratio. Units of time (such as seconds) seem then to work like currency units (such as dollars): they enter into similar ratios. We now encounter a similar problem when we attempt to determine the price of a dollar: money itself cannot have a price, since money itself is the measure of price (Chambers 2023a, 151).

In a monetary system, *prices* both measure this exchange value and set the rates of exchange. According to Geoffrey Ingham, 'the fact that "moneyness" is conferred by money of account becomes clearer with consideration of both the multiplicity and dissociation of money "things"' (Ingham 2013, 71). As used by Ingham, 'money of account' refers to the measure of abstract value. Since this is the aspect of money most comparable to time, it is this in which we are most interested in for this thesis. when we consider any sort of money regress, what we're interested in is this 'dissociation' whatever that might imply.

Since we're ultimately interested in an analysis of 'exchange value', we must look to real-world exchanges as our guides. Measurement will not be found in price alone but in the exchange practice it supports. In accordance with the formal structure of the TRA, the MRA will claim that, since money is itself the measure of value (that is, it tells us what something is worth), and the measurement units are expressed as prices in some

currency, money has no price, but rather is the expression of prices. I will refer to this as the 'Money has no value' argument. In Chapter 2, we saw two preliminary premises asserted by Price, in accordance with TRA. These premises are:

TRA P1: The flow of time must be expressible as a rate.

TRA P2: The flow of time must be expressible with the right sort of rate.

Using these and the further premises TRA 3–TRA 6, we were able to construct the full TRA. For an outline of the analogy between the TRA and the MRA, see Table 1.

Table 1

Time implies motion to be measured.	Money implies exchangeable value or worth to be measured.
TRA P3: If anything flows, it is sensible to ask how fast it flows.	**MRA P1:** If anything is worth something then it is sensible to ask how much it is worth.
TRA P4: In order to determine 'how fast' something changes, we must posit a separate time scale.	**MRA P2:** In order to determine how much something is worth, we must posit a separate worth scale (a money scale).
TRA C1: If time flows, it requires a separate time scale.	**MRA C1:** If money is worth something, it requires a separate worth scale (a money scale).
TRA P5: If a scale is a time scale, then it must flow.	**MRA P3:** If a scale is a money scale, then it is sensible to ask how much it is worth.
TRA P6: In order to determine 'how fast' something flows, we must posit a time scale.	**MRA P4:** In order to determine how much something is worth, we must posit a separate scale of worth (a money scale).
TRA C2: If we posit any time scale (n) we must posit another time scale (n+1).	**MRA C2:** If we posit any money scale (n) we must posit another money scale (n+1).

The TRA purports to show that time cannot 'move' or 'flow' in a meaningful sense, because it is itself the measure of motion. Scales or measures do not move or flow. Whatever flow there is must be our representation of the scale, not the scale itself. But note that, as we've constructed it, the MRA is structurally identical to the TRA. Money is itself the measure of exchangeable value, and prices are set in monetary terms. If the MRA is sound, then, since money can have no price, it has no value.[37]

As discussed above, the first hurdle for any analysis of the flow of time is assigning that flow a sensible rate. As we touched on in Chapter 1, Price thinks that for talk about

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[37] In the next chapter, we will return the question of whether money has any value or price. The MRA argument that I am presenting seems to be very similar to the TRA. Money, like time, is something special. It measures exchangeable value but has none itself.

something flowing to be 'sensible' there needs to be some sort of difference making. This is what I will refer to as Price's pragmatics test for sensibleness. We can put this as a question: if time does not flow, then what changes? If the answer to that question is 'nothing', then talk of time flowing is not 'sensible'.

We can ask a similar question about money. The question here is whether we can make sense of money having a price, and therefore establish that money has a 'sensible' value, in Price's sense. We can put this as an analogous question: if money has no value, then what changes? If we can make sense of money having a price, then because the TRA and MRA are structurally similar, we can make sense of time flowing at a rate.

The second hurdle for an analysis of the flow of time is whether time is dynamic in a way that can be captured adequately by some rate. In this chapter, I will address the first hurdle as applied to money. Later, in Chapter 6, I will argue that rate of exchange value captures the same kind of dynamism as the flow of time. The big question for money is: where does its value come from? The big question for time is: is where does its dynamism come from?

3.1 TRA P3

In this section I will formulate the analogous premise of P3 for the MRA. In order to do so, we need to revisit the *sui generis* argument from Chapter 2. Newton's approach, recall, is a possible answer to the TRA: 'Mathematical time, of itself, and from its own nature flows equably without regard to anything external' (Newton 1687, 77). This flow of absolute time is a 'gold standard rate of change and this gold standard is equable and immutable. Ned Markosian, in defence of a similar approach, claims that the pure passage of time offers a unique standard and holds a unique status among all changes:[38]

> I may choose to say that what is essential about rate talk is that it involves a comparison between some normal change and the pure passage of time. According to this view, it does not make sense to ask about the rate of the passage of time, for to do so is to make a category mistake: the answer would have to involve a comparison between the pure passage of time and the pure passage of time, but such an answer would not make sense because the pure

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[38] Markosian thinks that there is such a thing as a pure passage of time, but that rates can be interpreted in two ways. First, rate talk can be understood as a comparison between different changes, and sometimes that includes the pure passage of time. Second, rates essentially involve a comparison between rates of change and the rate of the pure passage of time. Understood in this latter way, any change in a clock, for instance, is just a stand-in for the pure passage of time.

passage of time has a unique status among changes-it is the one to which other, normal changes are to be compared. (Markosian 1993)

With this approach, other changes such as the motions of clock hands or material bodies may be called 'equable' *iff* they correspond exactly to this gold standard change, whether it is what Markosian describes as 'the pure passage' of time or what Newton refers to as 'absolute, true and mathematical time'.[39] As Forbes describes, 'the sense of change we are after is not to be analysed in terms of variation of one thing relative to another' (Forbes 2025, 3). And according to Broad, there is a difference between change *in* time and change *of* time (Broad 2014, 63). The question then becomes: how do these two changes relate? Supposedly, rates of 'changes in time' are grounded in change of time. In Newton's case, there is a substratum, absolute time, that grounds the facts of absolute rates independently of any comparative rates. But there is a problem with Newton's view. He claims that 'it may be, that there is no such thing as an equable motion, whereby time may be accurately measured' (Newton 1687, 78). If this is the case, then the gold standard for the rate of flow of time seems not to pass Price's test for 'sensibleness'.

More recently, Van Cleve has argued that we can ground facts about absolute rates in the pure passage of time without postulating substantival time. He argues that even Newton, if pressed on the matter, would have been happy to be an absolutist without being a substantivalist. According to this view, we should consider the pure passage of time to be this sort of absolute rate of change, leading us back to the tautological rate of 'one second per one second' (Van Cleve 2011, 155). The main take-away from Van Cleve's proposal is that comparative rates supervene on absolute rates. We may also see, in this proposal, an attempt to reconcile the *sui generis* argument with the 'one second per one second' argument. This thesis involves an attempt to make just such a reconciliation which relies on neither the same sort of tautology nor on the supervenience of comparative rates on absolute rates. In Chapter 6, I will present an argument for what I refer to as the 'impredicativity of totalities'. This view holds that any

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[39] In physics, time is what is measured by a clock. The traditional means by which time was measured was by comparison to motions; the Aristotelian view was that we apprehend time *through* motion. The more regular motions are viewed as the more reliable. The modern definition of time, defined by the transition between two hyperfine levels in the caesium-133 atom, is no longer appropriately described as a motion in the traditional sense.

adequate analysis of the things for which money may be exchanged must conclude that money itself is among those things. But leave that for later.

If money is analogous to time in the way I have described, and its rate of exchange value is analogous to rate of time's flow, we can make similar statements about money. If there is a gold standard for the rate of flow of time, there may also be a gold standard for the rate of exchangeable value. The obvious candidate for a gold standard of exchangeable value is gold. For 'metallists', precious metals such as gold and silver have a special status among things with exchange value: their value is that which all other things that are exchangeable are valued in terms of. One may then ask whether all exchange rates supervene on absolute rates of value.

This way of thinking has a considerable history, and this comparison between time and money occurs long before the Maudlin/Price discussion. There are two types of examples that Newton uses in *The Method of Fluxions and Infinite Series*. The obvious example is motion; the other, less obvious example is the time value of money and the present valuing of annuities (Newton 1736, 326). Newton's laws of motion are often claimed to be time reversal invariant. As far as I am aware no one makes a similar claim about valuing annuities.

A contemporary of Newton's, John Pollexfen, argued in favour of a standard of exchangeable value that captured the metalist intuition. In *A Discourse of Trade and Coin* Pollexfen argues that

> The chief use of coyn [sic], is to be a pledge, rule and measure in dealings, therefore its value ought to be certain, fixt [sic] and immutable. If any alteration be made, it will create not only jealousie [sic], but a necessity that more will follow, as in the like case hath always been practised in all countries. The coyn [sic] will no longer be a standing rule and measure for commerce but be as uncertain in value as other commodities. (Shirras and Craig 1945, 231)

What is of historical interest here is that Pollexfen wrote this as a criticism of Newton's monetary policy. He uses Newton's reasoning concerning time and motion and applies it to Newton's quite different views on money. Throughout the remainder of this thesis, I will return to the phrase 'certain, fixt and immutable' used above. I will try to argue that the idea that money has a value that is 'certain, fixt and immutable' is a bias displayed in much of our measurement practice.

Pollexfen's assertion above is that in order to measure, the measurement gauges we employ – whether money, sides of beef, or anything else – must be 'certain, fixt and immutable'. If my contentions about money are correct, then Pollexfen is wrong: we do not need measurement gauges to be 'certain, fixt and immutable'. If we take Maudlin's claim that measurement is not the right sort of concept to be at the bottom of physics, then when we speak of the rate at which time flows, we are making exactly the same kind of mistake (Robinson Erhardt 2024). Price makes precisely this mistake in asking for a sensible rate. Our measurement practice does not rely on scales that are 'certain, fixt and immutable'. Hence, insisting such a scale is needed and then concluding that time does not flow when one is not found reasons from a false premise.

Pollexfen's accurate measure of exchangeable value looks a lot like Newton's distinction between true and relative motion.[40] There might be all kinds of apparent fluctuations in value but if monetary value can be 'certain, fixt and immutable' then we can establish true value by measuring commodities against that value. Accordingly, Pollexfen thought that the certainty of the measure is grounded in the content of the coin: 'The true Intrinsic Value of Silver in Exchange of Silver ever was, and will be, an Ounce for an Ounce; an Ounce Coyned [sic] for an Ounce Uncoyned [sic]' (Newton 1701). Here again we see a 'one dollar per one dollar' position. At this stage, our main take-away is the 'one unit per one unit' rate of exchange frames the system by which exchange value may be measured. This is an important take away that can be applied to time.

What kind of distinction can be drawn between the uncertain value of other commodities and the fixed measurement of coin? Locke proposed that there is something intrinsically valuable about silver (Locke 1824, 82). The traditional early modern idea was that if something is worth something then the sensible way to determine is worth was to compare that object to something else that has an intrinsic value. If, moreover, this intrinsic value is not prone to change, it performs a similar role to an equable motion. There were two very good intrinsic value candidates, both of which are scarce and have use value. According to Locke,

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[40] According to Tim Maudlin, once we abandon Newtonian absolute time and the persistence of points of Newtonian absolute space, there are no objective speeds, either of light or of anything else. Once we abandon Newtonian spacetime, we need to choose coordinates that serve the role of absolute time and the rest as playing the role of absolute space (Maudlin 2015, 121).

[s]ilver, therefore, and silver alone, is the measure of commerce. Two metals, as gold and silver, cannot be the measure of commerce both together, in any country: because the measure of commerce must be perpetually the same, invariable, and keeping the same proportion of value in all its parts. But so only one metal does, or can do itself: so silver is to silver, and gold to gold. An ounce of silver is always of equal value to an ounce of silver, and an ounce of gold to an ounce of gold: and two ounces of the one, or the other, of double the value to an ounce of the same. (Locke, 1824, 151)

This is similar to Pollexfen's position. With Locke, what frames a metal, whether silver or gold, as stable in exchange is the convention of choosing it as the standard. He further acknowledges that, particularly in the case of gold and silver, a choice concerning which of these is to act as the fixed standard of worth and exchangeable value must be made. They cannot both play that function. (I will make more of this Lockean–Pollexfen argument in the next chapter.) This does not bear any obvious analogies to time. Obviously, one might think, there is exactly one true dimension of time. In my opinion, this simply imports the preconceptions at work in the silver or gold money example into a setting where they are inappropriate.

At this stage, it is worth returning to Barrow's views as discussed in Chapter 2. What happens when we choose an equable motion by convention, similar to the gold and silver example above? Callender considers just such a possibility. He envisions a scenario in which there are two equally good candidates for what Barrow described as the steady flow of time (Barrow 2008, 36):

This question is essentially about what to do if we have a "tie" in the best system competition between two (or more) equally strong and simple systems—each distinguishing a time direction orthogonal to the others. I don't believe that this is the case in a world like ours. Here the choice of time direction seems lopsided in favor of the one we pick. That said, I do believe that there is a conceivable state of affairs where this happens, and in fact, something like it once was considered as a live scientific possibility. The cosmologist Arthur Milne posited a cosmology with two times in it (Milne, 1948). In it, the ideal clock of atomic phenomena doesn't line up with the ideal clock for gravitational phenomena. One is logarithmically related to the other. Put in our terms, Milne found no good system wherein the one type of phenomena could be seen as marching to the same time as the other. In such a world we might consider there being a time for particle physics and a time for gravitational physics. (Callender 2017, 154)

As we already covered in Chapter 1, caesium clocks are the most accurate measuring devices we have: they give us an accurate measure, in seconds, of a particular

path through spacetime. If instead there are *two* fundamental times, atomic time and gravitational time, then we must make two more choices in order to frame our measurements. The first is the choice between atomic or gravitational. The second is the choice of rest frame.

With our current money practice, it seems farfetched to believe that either gold or silver can play the role of a 'certain, fixt and immutable' standard, and if they *both* play the role, neither remains 'certain, fixt and immutable'. As we found in the last chapter, precious metals have no fixed value; a fixed weight of gold may have a widely varying value. When doing physics, once we make a choice of a fixed standard for length or time (such as the one Maudlin suggests we make when we choose a coordinate to play the role of absolute time), we can derive coordinate speeds. Once we choose gold as our 'measuring frame', we can derive all other values and their changes. However, any potential changes in the value of gold are obscured by the gold 'measuring frame'. The units of this frame remain invariant only because we chose not to measure them.

The monetary concept equivalent to absolute motion or absolute time is intrinsic value. Some classical economists claimed that intrinsic value is grounded in labour (Smith 1982; Marx 1999; Ricardo 1992). According to this picture, value is grounded in quantities of effort or labour or some similar concept, which is considered to be more fundamental than value. This might be a way of talking which enables us to make claims about fairness and exploitation, but we are still faced with a measurement problem. The labour theory of value has its critics, of course. Joseph Schumpeter, for example argued that labour was irrelevant to any theory of value, as it was far too variable (owing to skills and situation) to ground any sort of intrinsic value (Schumpeter 2006, 311). So much the worse for finding agreement about what constitutes 'certain, fixt and immutable' economic value.

Surprisingly, Newton did not agree with Pollexfen. I say 'surprisingly' since, in the case of time, Newton thought that equable motions were a gold standard for measuring time. Such a motion would accurately measure absolute, true and mathematical time. In contrast, money was valued by what it enabled one to acquire. In response to Pollexfen, Newton wrote:

> Good security is a phrase which signifies security of the same value with money. So long as we believe it good so long we are content with it in lieu of

our money & when we begin to suspect its goodness we take in our money & return back the security. Tis mere opinion that sets a value upon money we value it because with it we can purchase all sorts of commodities & the same opinion sets a like value upon paper security. We value it because with it we can purchase all sorts of commodities & money too. All the difference is that the value of gold & silver is set upon their internal substance or matter & therefore called intrinsic & the value of paper security upon the apparent form of the writing & therefore called extrinsic & that the value of the former is more universal then that of the latter. (Newton 1701)

On this view, it is worth recalling the butcher shop example. Money measures exchangeable value and kilograms measures weight for one simple reason. This is more universal then if they were switched or we did away with kilograms altogether. The difference between intrinsic and extrinsic value is to be found in universal acceptance. It is convention that determines which is which. More importantly, money itself has a price. Its value can be measured in a system of prices. Can we hold the same view about the rate of flow of the passage of time? We might do this in one of two ways The first approach holds that money is the measure, is 'certain, fixt and immutable', and its exchange value is fixed merely convention: one ounce is worth one ounce because we say so. The other approach is that a rate of one unit per unit establishes a measurement for money itself; money is self-measuring. Again, so much the worse for a Pollexfenian valuer that is 'certain, fixt and immutable'. Unlike systems of measurement using units such as metres and feet, where there a fixed and unchanging conversion rate, monetary exchange rates fluctuate. A change of currency involves a changed measuring frame, similar to choosing a different coordinate frame with which to measure time.

In the next chapter we will return to the problem of intrinsic value, but at this stage the issue is whether we can, in the case of money, find a similar 'gold standard' that maintains the same sort of accuracy as an equable motion. It seems that we should be able to do this, insofar as we can make determinations about exchangeable value and the consistency of this value over time. If the pledge, rule, and measure fail to live up to being invariant, this failure should be measurable. We therefore can formulate an opening premise for our MRA analogous to the first premise of the TRA. Importantly, we must decide which coordinate plays the role of absolute time in order to then employ clocks and measuring rods as gauges with consistent units.

MRA P1: If anything is worth something then it is sensible to ask how much it is worth.

In this section, we must consider what it means to measure the gauge itself. In the case of time, we must consider how any change is measured.

3.2 TRA P4

Asking 'how fast' something changes involves asking for a system of measurement with units which measure quantities for time and distance. In other words, in order to make such a determination, we need another scale, just like in the case of time. In the case of the TRA, the proposed scale represents some quantity that is not already measured by time. According to champions of the TRA, an additional time scale carries ontological baggage. If we consider comparative measurements between one time scale and another it would not be too difficult to present such measurements in a table. Consider our example, in Chapter 2, which treats the game of cricket as a clock which measures units of legal balls bowled. This can be compared to any normal clock such as a watch. In this example we can have one time scale, in terms of balls bowled, and another time scale, the same one used by quotidian clocks. Those clocks in turn can be compared via convention to some standard like Geocentric Coordinate Time (TCG).[41] Since the general acceptance of relativity, the choice of clocks has become far more complex. There is no consistent, worldwide, shared path through spacetime. Even though we can more accurately measure proper time through any particular path through spacetime, choosing which path to measure has become much more difficult. Relativistic effects can be observed even on Earth. To simplify this decision, the TCG offers us a conventional standard, similar to Barrow's conventional choice of equable motion.

The additional time scale required by **TRA P4** cannot fall within the scope of what we take to be the fundamental measure, such as TCG. Our inferences are supposed to go

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[41] Geocentric Coordinate Time (TCG) is the time scale used in the Geocentric Celestial Reference System, the unit of which is the SI second. TCG differs from Terrestrial Time because a clock on the Earth's surface is moving with respect to the geocentric frame and feels the gravitational field of the Earth. Terrestrial Time is in effect a conveniently scaled TCG that differs from International Atomic Time (TAI) only by a fixed offset. The rate difference between TCG and Terrestrial Time is about 22 ms per year (Oxf. Ref., n.d.)r. TCG compensates for time dilation dues to the Earth because the reference frame for TCG is not rotating with the surface of the Earth and not in the gravitational potential of the Earth, TCG ticks faster than clocks on the surface of the Earth.

only in one direction. We can say that an over in cricket was faster or slower than others by comparing its duration to that measured by our terrestrial clocks. But when we talk about the TCG, we abandon this order of precedence. We hold that the TCG ticks faster than clocks on the surface of the Earth, rather than the other way around. The point made by the TRA is that in order to make a statement about the 'rate' of proper time as measured on Earth, we need to identify a quantity that is, in a specific way, just like that dimension of analysis. Here, we can draw insights from money yet again, specifically from monetary inflation. Even though one dollar is always worth one dollar, we can make sense of the value of the dollar changing by tracking the changing prices of commodities.

As I have argued so far, money is fundamentally a means of measure. This plays out in myriad circumstances. My local fruit vendor might sell mangoes for £1, and another business might sell them for £2. If I discover my local vendor is selling their mangoes for £1.50, I might be tempted to think they alone have raised their price for reasons particular to them. If, however, the business that sold them for £2 is now selling them for £3, I might conclude instead that the price of mangoes has risen generally. This reasoning extends to any number of commodities.

There is, however, a tipping point. If too many prices rise, and not enough prices fall, I would shift my explanation. This indicates, not a change in the value of the individual products, but a change in my means of measurement. This, roughly, is inflation: the measure itself loses value. Still, as I have argued, the pound still is worth a pound. The solution to inflation often pursued by central banks is to limit the money supply. One effective means of doing this, and one that Newton was well aware of, is to raise and lower interest rates (Newton 1701).

Do time or our temporal measurements exhibit similar behaviour? I think so. Proper time is one of the most accurate things we can measure. This measurement can be done with a caesium clock. To get the comparison to inflation going, let's return to Barrow. As discussed in Chapter 2, he proposed that any time-measuring instrument designed to be moved uniformly can be described as 'equable'. In the seventeenth century, it was thought that celestial movements were the most accurate measurements (Dolan 2025). Nonetheless, these movements were not the first measurements of time humanity ever used. Barrow observed that 'celestial Bodies were not essentially the primary and original Measures of Time. Rather all sorts of motions which are near us, that

strike upon our Senses, allow us to discover the Regularity of the celestial Motions' (Barrow 2008, 11). The Barrovian approach therefore leaves us with a picture of many different motions, each varying with more or less regularity than others. This seems analogous to the origin of money. In this analogy, irregular motions resemble products whose values are prone to large changes. A mango's price might fluctuate just as a long-distance runner's time on a certain track might fluctuate.

Barrow was doubtful that any measurement of time could be unalterable. He claimed:

> No one, for instance, can pretend to assert as a certainty, that the age of Methusalem(sic) himself, who lived a thousand years wanting one. was really longer than that of a man, who now does before he arrives at an hundred. (Barrow 1735, 11)

While Barrow did not have the benefit of caesium clocks, it is worth remembering that we adjust these clocks to correspond with the motions of our planet's rotation and its orbit around the sun. The universe is often claimed to be about 13.7 billion years old (Weintraub 2010). This age is measured in terms of our planet's current orbit around the sun. If we think of this as our clock, during at least the 4.5 billion years of this clocks existence there is a great deal of difference between one year and another. The earth revolved at different speeds, and it orbited the sun at different speeds. Still the determination of 13.7 billion is accurate enough but it is based on a current shared frame of reference.

The point that I am making is that the fact that some measures are *inaccurate* measures is often our evidence that other measures are *accurate*. I propose that something similar happens with our money practice. If a long-distance runner manages to beat her previous record, we would not automatically reason from that fact to some conclusion about the fundamental nature of time, just as we wouldn't automatically reason from an increase in the price of mangos to a change in the value of the pound.

But let us press the analogy further. What if we were to notice that many inaccurate, non-equable motions appear to pass more quickly? Examples of such changes include the rate at which Earth revolves on its axis[42] and the rate at which it orbits

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[42] There is currently some evidence to suggest that the Earth's rotation is faster than it has been in the past. According to a recent New York Times article "Our world's spins have been faster than usual lately. The

the sun. The general consensus is that the caesium clock is accurate enough to be a fixed standard. However, if we were to see all kinds of motions and changes speed up, just as in the case of inflation, we might not ground this in changes in individual motions but rather to a change in the rate of time's flow. No doubt this example is fanciful, but it serves a demonstrative purpose: in such a case, no separate time scale is required.

Why does each temporal scale need its own way of extending or enduring? This is the source of the ontological baggage highlighted by the TRA. As Broad pointed out in the previous chapter, if presentness consists in sliding along one time scale in relation to another time scale then 'How great a lapse of time 1 does presentness traverse in a unit of time 2?' Again, a regress of time-dimensions is imminent (Broad, C.D. 1938).

What is the monetary analogue of distinct temporal scales? It is that every currency has a price system. Each currency can be analysed in relation to any other currency. It is also difficult to determine which of these currencies is more fundamental – indeed, it is not completely clear whether the question makes sense. Currencies, as money scales, do not carry the same ontological baggage as do temporal units. That isn't the point, however. If we recall, for Price, it isn't the ontological baggage that is the problem, it's that the entire concept of the flow of time is incoherent. Thus, even though these features of currency say very little about how ontologically explosive the TRA is, they might provide a guide to showing whether the flow of time is coherent.

We might illustrate this with the following example. Suppose I find myself in a farmers' market in Nigeria. In this market, the prices of the various goods are expressed in ₦ (naira), as in this particular community, the naira is the measure of commerce. As a tourist, however, I have not earned any naira. I am not accustomed to measuring value in naira. In a situation much like that of learning a new language, I need to translate this new measurement into another with which I am familiar. My starting point is that I must exchange something in order to acquire naira. For example, I can go to the bank and buy naira with pounds. There is a price for naira expressed in pounds. While the community that I am engaging with treat naira as the more fundamental measure of commerce, from my point of reference it is the pound that underlies my assessment of the value of various

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average day has mostly shortened over the past decade, and within the past five years or so, the full rotation has clocked in at a hair less than 24 hours more often than not" (Fortin 2025).

goods. The Naira are simply something I must acquire, using pounds, in order to exchange for those goods.

Let us now ask what the naira is worth. Obviously, in maybe the most straightforward sense, one naira is worth one naira. But in the farmers' market I can buy all kinds of produce using these naira, so in another sense (that of exchange) one naira is worth at least those goods which I can purchase using one naira. (This is much like the example of time-measuring motions.) In still a third sense, as in the example of cricket overs, we can compare the naira to some external reference. In the cricket example this is a clock. In the case of the naira, we can compare it to the pound sterling. This satisfies **MRA P2.** This means that likewise, **TRA P4** can be satisfied in a formal sense without entailing **TRA P4***.

Even with an outside scale of worth, in the form of pounds sterling, we have not stopped the regress. Since the 1944 Bretton Woods agreement, the dollar serves the function that gold once did (Williams 1945). Given the present system, the regress ends with the dollar. If we were metallists, and held the opinion expressed by Locke earlier in this thesis, the regress would end with silver. Either of these, depending on our position, plays the role in our monetary discourse that pure passage does in our temporal discourse.

So far, we have five distinct money scales that we can reference at this stage: naira, pounds sterling, the dollar, gold and silver. Here there is not any particular reason to think one level of this regress is more fundamental than any other. This seems different from time. There, the suitability of the caesium atom as our 'best' clock is determined by how closely it corresponds to an equable measure of time. Indeed, it is perhaps the most accurate thing we *can* measure. We are not without choices; we have to choose a coordinate to play the role of absolute time. We will have to return to this in the next chapter. At this stage it is worth remembering that we choose different frames of references for different purposes as is the case with the TCG.

What is different at this stage of analysis is that in the case of money, I can just as easily ask what a Dollar is worth in terms of naira. We do not have to posit any further dimensions of extension even though there are obviously lots and lots of dimensions of analysis. Newton's claim, recall, was that the only difference between intrinsic and

extrinsic value is the merely conventional standard of being closest to universally accepted. With the advent of relativity, we find ourselves in a similar predicament when attempting to determine some 'fundamental' measure of time.

The key point of the MRA is that unless the exchange value of any monetary unit was fixed in terms of another linchpin commodity, this value would vary from trade to trade for the same commodity. A recent proponent of this position is Ingham (2013). Ingham argues that for an emergent spontaneous currency to come into existence, it requires another monetary system to exist as a money of account. There is a counter example. One example of such a spontaneous currency was cigarette currency that emerged during the economic exchanges between prisoners of war during the Second World War.

According to Ingham's model, the value of cigarettes must regress to some other money. Ingham claims that 'for the cigarette to be a money of account, as opposed to the commodity that would be traded for all others, its value would have to be stabilised in some other way in relation to another commodity' (Ingham 2013, 25). The backstop or end of the regress requires some sort of authority, which stipulates a fixed exchange rate and therefore brings about a stable system of prices. It is this stipulated fixed exchange rate that makes something count as money. With this in mind, Ingham claims that the way money accounts for value (via some form of abstract value) must precede market exchange. This abstract value is traditionally construed as exogenous.[43] In this thesis, I reject this view. Rather, I contend, it is exchange that is the very process of measurement. The model that I am championing is endogenous. Monetary endogeneity refers to the idea that a nation's money supply is primarily determined by the needs of the real economy rather than a central authority. The money supply thus expands or contracts based on the demand for credit and loans from businesses and individuals. The adjustment of interest is a reactive process of the central bank in order to maintain accurate measurement.

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[43] In the traditional exogenous money model, the quantity and value of the money is set outside the money system. This is obviously the case when we consider metallism. It is the fixed quantity of the metal that is exogenous to the money practice. With credit money, this is not so obvious. According to Ingham 'orthodox exogenous money theorists acknowledge that the banking system creates credit-money but insists that the central bank is able to exercise *control* over this process by its power to create the 'high power' - base money reserves for the system' (Ingham 2013). On the other hand, it seems to be a natural consequence of money's measurement function that it is endogenous. Money consists of endogenous variables whose values are determined by factors within the model.

From this analysis, we can construct an analogous premise to **TRA P4.** However, unlike in the case of money, an appeal to some authority is not open to anyone who wishes to respond to the TRA. It is implausible to claim that time flows merely because the sovereign says so.[44] For champions of the TRA, appeals to the pure passage of time looks equally *ad hoc*. The desired premise is:

MRA P4: In order to determine how much something is worth, we must posit a separate scale of worth (a money scale).

Note that in this case, moving from cigarettes to naira to dollars is unproblematic. Once we have these two premises, we can draw an analogous conclusion to that of the TRA:

MRA C1: If money is worth something then it requires a separate worth scale (a money scale).

There is a notable difference between the conclusions of the TRA and the MRA. I think this difference matters. The main target of the TRA is the geometry of spacetime, where we take for granted that there are three spatial ways of extending. If, in the case of the TRA, a separate time scale requires the postulation of an additional way of extending or enduring, then we are positing additional dimensions of extension as per **TRA P4***.[45] The resultant ontology, one might think, is objectionably bloated. The worth scales, by contrast, are not thought of as dimensions of extension even though we are treating them as dimensions of analysis, and thus carry no extra ontological baggage. This is why the MRA is analytically helpful.

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[44] Of course, one sovereign that one could appeal to is God. This is not what I mean here but it is worth considering. However, it is worth pointing out that this option is closed to Newton's account of space and time. According to Newton, God, space and time are coeternal. Furthermore, on his view, space and time are distinct from God. Everything, including God, is in space and time. Combine this with Newton's claim that 'time flows equably without relation to anything external" and the idea that time flows because the sovereign says so becomes difficult to reconcile with Newton's sempiternalism.

[45] At this point, it is worth remaining neutral to the question of whether there is a distinction between enduring or extending. If enduring is just a way of extending, then we need to postulate another time dimension that extends. If it is a way of enduring, then we need to postulate another time dimension that endures. J.C.C Smart most clearly articulated this view: 'First If time is a flowing river we must think of events taking time to float down this stream, and if we say "time has flown faster today than it flew yesterday" we are saying that the stream flowed a greater distance to-day than it did at the same time yesterday. That is, we are postulating a second time-scale with respect to which the flow of events along the first time-dimension is measured' (Smart 1949, 486). He goes on to further claim what I think is the ontological problem in the TRA. Just as we thought of the first time-dimension as a stream, so will we want to think of the second time-dimension as a stream also.

As stated earlier, there is not any reason to think that any one money scale is more fundamental than any other. Naira are not more fundamental than euros. Since every money scale measures every other money scale, we must either accept that the money practice is 'impredicative' (in that it generalises over a totality of all exchangeable things including other money scales) or we must terminate the resultant regress in a non-money scale, in which case we have a measurement problem that is similar to the TRA. I am specifically arguing for the *'impredicativity of totalities'*. In the next chapter we will return to this impredicativity. We will also review this problem of self-reference with respect to totalities in Chapter 6. One obvious response the proponent of the TRA might offer is to simply ask whether money is simply one big group delusion (Chambers 2023a, 3).

3.3 TRA P5

Anyone who accepts this premise is committed to the view that the properties of the scales used in the analysis must be the same, or at least relevantly similar. In the case of time scales, if the first scale has distinct temporal properties of flow, then so must all the others, because they fundamentally do the same thing.[46]

The equivalent position for the MRA is not much different. We might add an additional scale that is like the scale being measured, in the sense that it values or measures value. For 'The Cigarette' to be a reliable measure such that it can function as a unit of account, its value would have to be stabilised in some way beyond the collective and conventional attitude, held by those who use it as a unit of exchange, that its value is 'certain, fixt and immutable'. In the naira example, one monetary scale can be stabilised *vis-à-vis* another similar scale such as the pound, which can in turn be stabilised by the preferred reserve currency of the Dollar. Were we still operating under the Bretton Woods system, we could make one regress more, to gold. The claim that each additional scale maintains its 'time scale' property of flowing is an absolutely essential feature of the TRA, and will remain the case unless we postulate a terminal scale which does not have the 'time scale' property of flowing. We will need to return to this in the next chapter.

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[46] Returning to Smart, the problem the TRA highlights is that streams flow. Using a stream as a scale means that along each successive stream, prior time streams flow. If this sounds odd, this is precisely the problem that the TRA is meant to highlight.

The important distinction here is that it is exchange, rather than price lists and ledgers, that constitutes the practice. This exchange does not just consist in what Searle refers to as assertive speech acts (Searle 2008, 451), as the direction of fit in question is not word-to-world. It is not enough to say that the dollar is worth 1,600 naira. This price must correspond to what is actually being exchanged. How the rest of the world responds matters. As Searle claims, 'we create money, government, private property, and marriage, for example, by representations that have the double direction of fit' (Searle 2008). This double direction is both word-to-world and world-to-word. (This again hints at money being impredicative.) Transactions don't just measure the things being purchased but also the currency used in exchange.

In the Maudlin/Price discourse, Price makes the following claim.

> In reply to Maudlin's suggestion, consider a graph of the amount of money I give you in currency X, against the amount of money you give me in currency Y. On such a graph, there is a straight line marking the fair rate of exchange: as Maudlin says, exchanges taking place at points on that line can be interpreted in terms of equal purchasing power. And when X and Y are the same currency, the slope of that line is 1. (Price 2011b, 304)

In this reply, Price highlights what is problematic about the given analysis. We will not see a linear relationship in price between two distinct currencies X and Y, simply because of what Searle refers to as the feedback loop of world-to-word. Again, this hints at impredicativity. The larger the transaction size, the greater the adjustment of the exchange rate. What neither Price nor Maudlin account for is that 'fair rate of exchange' is not 'certain, fixt and immutable'. As Price recognises, however, when X and Y refer to the same currency, the slope is 1. Regardless of the size of our units, the 'one dollar per one dollar' relation holds. We may imagine one currency trader asking another currency trader to buy a 'yard' of Dollars for Dollars at the spot rate.[47] The other trader would likely not even be able to understand what is being asked. There is no way to account for such a transaction. In such a case, I argue, we are talking about the 'very same thing'. If we apply a duration to the contract, then that is something entirely different. In chapter 6, we will examine yield curves and how we should interpret the future trading practice.

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[47]The term 'yard' is a financial industry word derived from the term 'milliard', which is used in the United Kingdom and is equivalent to the American English 'one billion'.

We now come to another premise in the MRA:

MRA P3: If a scale is a money scale, then it is sensible to ask how much it is worth.

What this premise says is that if each unit in currency scale 1 is worth something, then the units measured in currency scale 2 must also be worth something. A naira is worth something, and if I measure that naira in pounds then, as expected, a pound is worth something. But this analysis seems to have a gap. While I might measure naira in pounds, I might with equal right measure pounds in naira. One main desideratum of the TRA is that a rate requires what sits in the numerator position to be distinct from what sits in the denominator position. These monetary units, however, seem to be measuring the same thing, and they can be substituted to a certain extent. We will analyse this issue in the next chapter. On a small scale, we may translate between units of different currencies in much the same way we translate between yards and metres. However, at the macro level, each transaction changes the rate of exchange. Hence, at the macro scale, the numerators and denominators are distinct.

Apart from the issue of substitution, in the case of money, it is not at all clear that each additional scale must be the same as or relatively similar to the previous one. Naira, pounds, and dollars do follow the form of **TRA P5.** But gold and silver are supposed to be something which is not money but is yet valuable. As Ingham proposed, this valuing will come from some authority. The thought is that its exchange value will not be based on some other currency scale. Instead, like an ideal clock, it corresponds to value *simpliciter*, in much the same way that the pure passage of time corresponds to passage *simpliciter*. It is the thing from which all other values derive their value. It is a terminal scale. In contrast, I am arguing that there is no such terminal scale in the money practice.

3.4 TRA P6

According to the TRA, for a ratio to be a rate, what sits in the numerator position to be distinct from what sits in the denominator position. At some point, the MRA must terminate in something where the 'how much' question is infelicitous. In the case of the TRA the conclusion is **TRA C2:**

TRA C2: If we posit any time scale (n) we must posit another time scale (n+1).

The MRA conclusion follows the same form.

MRA C2: If we posit any money scale (n) we must posit another money scale (n+1).

There is one *prima facie* difference between the money scales and time scales: no money scale has the same claim as a time scale on fundamental temporal dimensions of extension/duration. This comes at a price: there is no order of ontological precedence or fundamentality. The price of naira as set in Dollars is just as fundamental as the price of Dollars in naira. Each functions equally well as a frame of reference for setting prices.

It is 'mere opinion', to borrow Newton's vocabulary, that accords the Dollar greater fundamentality *qua* money scale, because of its reserve currency status. There is not anything intrinsic about the Dollar which forces this choice on us. The reserve currency could just as easily be the naira and maybe someday the Naira will be a reserve currency. Each of these monetary units treat other currencies as commodities that are measured through a price system. Money thus seems to be impredicative. There are chains of self-reference.

In Chapter 1, I claimed that we must ask similar questions of both the TRA and the MRA in order to compare the 'sensibility' of rates. This comparison does just that. In the case of the MRA, 'one dollar per one dollar' makes the sort of difference that the pragmatic test discussed earlier requires.

But there are some important differences between these two arguments, so some necessary adjustments need to be made. The most notable of these is how, in the TRA, we must postulate additional ways of extending, but we need do no such thing in the MRA. As we covered in the previous chapter, Smart begins his discussion with talk of scales. It then moves on to talk of dimensions as per our measurement practice, and finally arrives at something more fundamental: dimensions of extension. In the case of the MRA, the rates we use for most practical purposes do not obviously supervene or require the existence of absolute rates. This notwithstanding, something like absolute rates have been postulated. Furthermore, in the case of the MRA, the money scales in the regress do not get successively more fundamental as the regress goes on. Rather, these scales cross-reference each other. In the next chapter, we will investigate the extent to which our money practice is impredicative. If it is, then we have a solution to the TRA, and can avoid postulating anything like supertime or meta-time (see pages 16-17).

What we still need to do is address Price's 'very same thing' claim. This will require a deep dive into the ontology of money. My argument will be that units of currency, such as the pound sterling, are more like seconds than Price thinks: it is an abstract measure that, when properly framed, produces units which exhibit the 'very same thing' relation to one another. What we are after, recall, is a way of applying an answer to the MRA *mutatis mutandis* to the TRA. In the next chapter, we will do just this. The most notable point of the discussion below will be whether we can give an impredicative account of the rate of time's flow. In other words: when we measure motion with time, are we also measuring time with motion?

Chapter 4: Money: The Universal Equivalent

They cannot bring their commodities into relation as values, and therefore as commodities, except by comparing them with some one other commodity as the universal equivalent. (Marx 2019, 98)

4.0 Introduction

This chapter has two goals. The first goal is to give a sensible account of impredicativity, particularly when applied to rates. The second goal is to export the account of impredicativity developed for money to an analysis of time, using the approach to rates that this chapter develops. In Chapter 3, I established that generalising over totalities involves self-reference (see page 73). This is the *impredicativity of totalities*. It is central to our measuring practice because thinking of something as fungible involves self-comparison. Moreover, this substitutability maintains transitivity (quantitative equality is usually thought to be transitive). The TRA says that because rates like 'one second per one second' are impredicative, they're defective. Trying to employ this in an account of the rate of time's flow yields a 'tautological rate' (Van Cleve 2011, 149).

The MRA offers a direct analogy. Moreover, there are, in the discourse on money, objections that are similar to the tautology objection, which thus have relevance for an analysis of the rate of time's flow. This chapter will review one such argument, made by Samuel Chambers, which I will refer to as the 'money has no value' argument. This argument is remarkably similar to Price's 'very same thing' argument, covered in Chapter 1. Moreover, it is congruent with Callender's claim that money is not something we value 'in and of itself'.

Contra Chambers, I will argue that the price of one dollar is one dollar. This will involve giving an intelligible account of impredicativity. The money universal demands maximal fungibility (Reden 2010, 4). Commodification fundamentally involves treating physical objects as fungible. It is no coincidence that coins, as money, are minted out of a fungible commodity such as gold, silver or brass. It is this fungible characteristic of money units that distinguishes the money practice from barter exchange. However, this means I need to give some sort of origin story for money, and this story must have a selection mechanism based on fungibility. I will argue that Gresham's law is such a

mechanism.[48] Broadly construed Gresham's law states that bad money drives out good. I will also argue that Gresham's law is evidence of this fungibility, and that we can make sense of impredicative rates owing to what I call the *impredicativity of rates principle*:

Impredicativity of rates principle (IRP): Impredicative rates are 'sensible' *iff* the units that the quantities describe are maximally fungible.

I anticipate the following objection. Throughout the history of the money practice there are examples of currency units being instantiated or tokened by non-fungible things. For example, there are individual coins with various sovereigns' heads, or bank notes with individual serial numbers. Though they share certain features, each physical object is particular and individuated from every other.

I will respond accordingly. If I am right, then these physical attributes work against the ability of these objects to token the currency unit. The currency unit itself is abstract and not at all made of distinct parts. This is the only way that substitutability, transitivity and fungibility can be maintained. As A. Mitchell Innes puts it, '[t]he eye has never seen, nor the hand touched a dollar' (Innes 2004, 155). To the extent that currency tokens are non-fungible, that currency functions less like money. We take money to bear a value in itself. This is what Sgambati describes as the 'Janus-faced nature of money' (Sgambati 2015, 314). My thesis here is that 'the process of exchange also produces the measure'. To play the role it evidently does play in economic exchange, money must be conceptualised both as a value and as a measure of value. This is the essence of the impredicativity of rates.

So much for money. Is there a 'Janus-faced' nature of time? I believe so. 'The second', like the 'the dollar', is a unit of measurement that is both a universal and particular. Innes' claim above holds true of fundamental measures such as a metre as well: the eye has never seen, nor the hand touched a metre.

The second goal of this chapter is to give an account of the correct interpretation of rates. I will continue to argue that the *no impredicative* version of the TRA doesn't do

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[48] Gresham's law states that " when two moneys are forced to exchange at relative prices different than their inherent values , the money with less inherent value will drive the dearer money out"(Mishkin and Serletis 2019, 476). In short bad money drives out good. The terms are deceptive. The good money refers to currency tokens that have ancillary worth. That is value that is subordinate to their value as currency tokens. Silver in a gold back coin is subordinate to its tokening of some nominal gold quantity. Bad money in comparison has less ancillary worth. In this case less silver.

what it purports to do. It does not demonstrate that time does not flow. Time does in fact flow, at an impredicative rate of *one second per one second*. But why think that impredicativity applies to time as well as money? For precisely the same reasons as for money, I will argue. In Chapter 1 we covered how the TRA leads us to question whether it is sensible to claim that time flows. In the case of money, the MRA leads us to question whether money itself has a price. Pollexfen, as covered in Chapter 2, argued that 'pledge, rules and measures' need to be '*certain, fixt and immutable*'. How can something whose exchangeable value varies measure exchangeable value? Aren't fundamental measures such as metres and seconds 'certain, fixt and immutable'? In my view, this is the wrong way to interpret rates. Since the advent of relativity theory, seconds and metres are relativised to a frame of reference. Because it lacks a certain sort of objectivity, measurement is not the right sort of concept to be sitting at the bottom of physics. In this chapter, I will argue that the correct way to interpret rates is to apply the following principle:

Frame of reference impredicativity principle (FRIP): Fundamental measurement is always frame dependent, where the origin of the frame represents maximal fungibility of the measurement unit.

We should take this impredicative feature seriously and apply it to time. Self-referential rates can make sense, and money proves this.

As covered in Chapter 1, Price asks for a notion of flow, or flux, which would capture what's supposed to be special about time (Price 2011b, 304). According to him, a rate of flow of 'one second per one second' does not do that, and I agree. Price, however, thinks that it is the wrong sort of rate. I do not expect that by merely refuting the TRA I will entirely convince those with B-theoretic deflationist sympathies. What I am doing is raising the plausibility that time is dynamic. In this regard, I agree with Michael Raven's assessment, 'the issue of rate is a red herring' (Raven 2011, 11). The second goal is to argue for the correct way to interpret rates. It turns out that rates are a red herring when we apply **FRIP.** The question of whether reality is dynamic isn't to be found in a rate of this dynamism but rather what it could be for reality to be dynamic. I agree that there is not anything dynamic in the mere rate of 'one dollar per one dollar' or 'one second per one second'. Central to my view is the idea that the rate of 'one dollar per one dollar' constitutes a starting point for analysis. Prior to this time there are no prices. In the money

practice, this constitutes the frame dependence of the measurement as per **Frame of reference principle of Impredicativity.** The reference frame can't be separated from the measure.

This chapter has four sections. The first argues that what distinguishes currency units is their fungibility. The second discusses Gresham's law and the selection process that makes currency units abstract. The first two sections will focus on achieving the first goal. The last two sections will focus on achieving the second goal. In the third section I will identify three distinct abstractions: the money universal, individual currencies that instantiate this universal, and various ways of tokening these currency units. This threefold distinction, incidentally, is also Price's response of 'The dollar you give me and the dollar I give you' to Maudlin does not work. Finally, in the fourth section we will examine the time value of money. Parsing the synchronic and diachronic components of an analysis of currency units will be our starting point for determining the feature of money (and therefore time) in which we should locate its dynamism.

4.1 Fungibility

"Now by wealth we mean all the things whose value is measured by money".
(Aristotle 2014b, 1119b20)

There is broad agreement that money measures (Keynes 2018b; Mäki 2021; Chambers 2023a; Sgambati 2015; Aristotle 2014b). There is also broad agreement that money perform other functions. In this chapter we are specifically interested in its measurement function. In later sections we will revisit other ones. I will therefore discuss the degree of fungibility expected from measurement units. The money practice seems to require fungible units. There is a process or mechanism that selects for fungibility, and this leads to what I refer to as maximal fungibility of the measurement units. I will argue that this process introduces a degree of self-reference. As currency units approach maximal fungibility, they also approach impredicativity. There is a complication here, however. Currencies, as I will demonstrate, approach maximal fungibility synchronically but not diachronically. I refer to this as the *diachronic defeater*.

At this stage, it is worth keeping in mind the overall goal of this thesis is to provide a flow-invoking explanation of the passage of time. Olson writes that '[t]ime is dynamic,

because at certain times evaluations are absolutely present and there is continual change as to which ones are indeed present' (Olson 2009, 3). The same is true for money. Therefore, I am also arguing for a flow-invoking explanation of money. My strategy involves picking out an 'objective present', at least in the money practice. This is represented by what I call the 'zero-starting point', which continually changes. This will dovetail with the second goal of this chapter: establishing that the **FRIP** is the correct way to interpret rates.

In order to get there, we need to determine whether it is reasonable to think that what each instance of 'second' in the exchange rate of 'one dollar per one dollar' refers to bear the 'very same thing' relation to one another. Moreover, we need to parse what such an exchange says about synchronic identity. If a thing bears this 'very same thing' relation to something else, then it is identical to that second thing and fully replaceable by it. Quantitative equality is generally taken to be transitive. If dollars are maximally fungible, then all dollars are in that respect identical. Samuel Chambers holds a view about money that is analogous to the view of time held by Price. He summarises his claim as follows:

> We cannot measure the value of money in price terms (i.e., in terms of money): first, because as we have argued throughout, money has no value; but second, because such an expression would be nonsensical. What is the price of $4? Would we really want to answer, "$4"? The equation $4 = $4 does not express the price of money; it is merely a senseless tautology. (Chambers 2023a, 151)

Chambers thinks that measurements have a distinct ontological status from what they measure. Kilograms are a measure of weight, but they do not *have* weight. Likewise, 'money itself cannot have a price for just the reason that money is measure' (Chambers 2023a, 151). My answer to Chambers' rhetorical question ('Would we really want to answer, "$4"?') is, simply, 'yes'. To riff on what we saw Maudlin say in Chapter 2, imagine one's surprise if offered any other price (Maudlin 2007, 112). Moreover, Chambers' analysis is mistaken for the same reasons that Price's is. The 'second' is a duration of one second, and passes at a rate of one second.

Measuring value presents a challenge. Value is quantified in terms of money units, yet this makes money seem or appear to *be* value. Chambers thinks that money cannot itself be value because money is never the site of positive or intrinsic value. In my view,

this is precisely the problem with Chambers' reasoning. The rate of 'one dollar per one dollar' might be tautological in that there is mutual definition but certainly is not 'senseless'.

As Chambers sees it, there is a money paradox. First, money is not what it seems to be; and second, what money is depends on what it seems to be. These positions must be reconciled. I will argue that money comes about via a selection mechanism, and this mechanism resolves the paradox. This supports our first goal in this chapter, since the **IRP** involves a selection mechanism towards maximum fungibility. In this respect I disagree with Locke, Smith and Ricardo. It is implausible that individuals in a state of nature will simply agree to use money (Chambers 2023a, 94); It does not seem plausible that such a deliberate convention can explain the universality of the money practice. Something else must be in play. Instead, I claim that money is unintentionally selected for because it measures in a particular way. What I think is missing from the account offered by Locke, Smith and Ricardo is that money is centrally about *exchange*. This exchange constitutes the act of measurement.

There are three dominant theories of money: commodity money, credit money, and fiat money. (At this point it is worth pointing out that Chambers defends the credit theory of money.) In the next section, I will discuss the consequences this position has for our measurement practices. Central to what I am claiming is that money arises often unintentionally and yet it also has hypostasis. Therefore, I need to give an origin story for money. At this point, the commodity theory offers what I think is a good explanation of the origins of money.

According to Menger's theory of money, money is selected based on the most 'saleable commodity' (Menger 2009b, 36). This idea has two important takeaways. The first and most obvious is that commodification is the act of treating things as fungible. The second is that we can order saleability from less saleable to more saleable. As Menger correctly recognised, superior saleability depends only on the relatively inferior saleability of every other kind of commodity (Menger 2009b, 36). This should sound familiar: it is the same sort of origin story that Barrow gives for our measurements of time. This idea of saleability as broad and frequent acceptance leads to money being described with the analogy of flowing water, just as time is. The money universal consists

of currencies as in a currents in water. Hence this universal implies flow. Currency units are also described as the most liquid of assets. Again, liquidity implies flow.

As we saw with Newton in the last chapter, intrinsic value is a red herring. What we are really talking about is broad acceptance in exchange. An alternative view is offered by Stefano Sgambati: participants in the money practice are capable of grasping money as both universal and particular at the very same time (Sgambati 2015, 314). In this way, we treat tokens that are not fungible as though they were. Still, in our analysis of Gresham's law, we will see that any time there is individuation, there is the potential for uncertainty in value.

Let us return to Chambers' argument. He thinks that there is something objectionable about the equation '$4 = $4' to the extent that it represents a genuine price:

> We might find a clue to the nature of money by looking at the US $20 bill or the UK £5 note. On the top of the latter, we find these words: "Bank of England / I promise to pay the bearer on demand the sum of Five Pounds" The paradox of money flashes here, written down for all the world to see, since in one sense these words make no sense whatsoever. The £5 note states that its possessor can exchange it for £5. But if I already have £5, why would I want to swap it for £5? What would that even mean? And if possessing a £5 note only guarantees that I can swap it for a £5 note, then what is a £5 note to begin with? We seem not to have answered the question, "What's £5?". (Chambers 2022, 71)

Here we see Price's 'very same thing' argument being applied to what Price claims sets the 'second' apart from the 'dollar'. In my view, Chambers has identified a very puzzling characteristic of money, as opposed to individuated tokens. If I have an ounce of gold this ounce is obviously equal to itself. It is identical. It is the very same thing. We also presume that it is equal in value to another ounce of gold. To paraphrase Price, there is the gold ounce *you* have and the gold ounce *I* have. There is no need of any statement about this ounce of gold being exchangeable for itself. While commodification is precisely the process of making things fungible, what Chambers has brought to our attention is that this process can stretch beyond the physical object that is the commodity. The bank note is not really the five pounds it proports to be. It tokens this abstract thing called the pound. In Chapter 6, I will apply this reasoning to currency trading in large size transactions. We can think of the problem synchronically, just a Chambers puts it: 'I already have £5, why would I want to swap it for £5? What would that

even mean?' (Chambers 2022, 71) Whatever maybe the answer here, diachronically we clearly *can* make sense of this exchange, as we actually do have loans and monetary discounting.

This section is concerned with giving an explanation for the extent to which currency units are fungible. What I will argue is that there is no practical distinction between *representing* or *instantiating* money and *being* money.[49] There are two distinct ways to parse this. The first is the sense Newton recognises: there is no real difference between paper security and silver money except for the level of broad acceptance. As we saw with Menger, some commodities are more saleable, but this is only in comparison to other commodities.

There is another way to parse this lack of distinction that is equally applicable. Pounds, euros, naira or yen, as currencies, equally instantiate or represent the money universal. As I have already claimed, there is a money hypostasis. Money thus has a permanent measurement feature. This second way of parsing the claim above will advance our first goal of demonstrating that impredicative rates are possible and unproblematic.

This building block sets us up for the second goal of this chapter, showing that impredicativity offers the same solution for time. The fact that interest rates change over time will show us what is dynamic about time, because it demonstrates that there are some evaluations that are absolutely present, and there is continual change as to which ones they are. This constitutes the **FRIP.**

One snag here is that evolution over time is a diachronic concept, whereas a price system is relative to what I refer to the 'zero-starting point', which is a synchronic concept. All prices are relative to a particular time slice represented by the 'zero-starting point'. This point is not spatially localised. Spatially, money can be described as allocentric, but temporally it is localised to one time slice. It is temporally egocentric. In this respect, dollars differ from seconds in that a second needs to be relativised to a frame of

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[49] At the time of Newton and Locke there were, and today there still are, two schools of thought as to what paper security represents. One school was that of Locke and Pollexfen, which claimed that paper security merely represented money. Silver was *real* money. The other, Newtonian school claimed that paper security was just as much money as was silver because both can be used to purchase commodities (and money) just as easily. All money can thus equally be thought of as fiat. There is then no distinction between representing and being money.

reference. This frame of reference is localised to a 'here' and 'now' in spacetime and can be represented as an event with a light cone structure.[50] In the case of money, maximal fungibility goes hand in hand with a 'zero-starting point'. At every time slice the dollar is worth a dollar but this does not mean that these dollars are worth the same. They are not fungible. They can buy different things therefore they have different prices even though they are always exchangeable for a dollar. Again, this is what I refer to as the diachronic defeater.

The traditional early modern idea was that if some object or experience has a worth then the sensible way to determine this worth was to compare that object or experience to some other thing. When determining a thing's value, the comparison should bottom out with some object that has intrinsic value. The idea is that something that expresses intrinsic value is not subject to change. This was a monetary equivalent of finding an equable motion, and was (and still is) the basis for metallism. As discussed in the previous chapter, according to Locke, '[s]ilver… and silver alone, is the measure of commerce. Two metals, as gold and silver, cannot be the measure of commerce both together, in any country' (Locke 1824, 151). The puzzle here is that both silver and gold meet this criterion of fungibility to an equal extent.

It is worth remembering that I am applying a Barrovian account of the flow of time, because like Barrow's account of equable motions, the money practice is essentially conventional. It is not a matter of determining which metal more accurately tracks commerce and is therefore a better measure, but rather of choosing one metal and thus setting 'the same proportion of value in all its parts'. It is possible that, in Locke's time, there were times where a small gold coin was worth the same as a much larger silver coin. This challenges Menger's account, since there might be two commodities which are equally 'most saleable'. Such a situation creates a measurement problem. As Locke points out, 'the measure of commerce must be perpetually the same, invariable, and keeping the same proportion of value in all its parts' (Locke 1824, 151). Here he seems to

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[50] One possible example of impredicativity in special relativity is this light-cone structure. Each direction along the light cone is orthogonal to itself (Knox and Wilson 2021, 63). In Euclidean space, a vector is orthogonal to itself if its 'length' is zero. In Chapter 6 we will encounter, in the yield curve structure, a sense in which time is orthogonal to itself.

contradict a position he holds elsewhere, that money is treated as though it is a standing measure but if the quantities of money change then it is not (Locke 1714, 22).

However, saleability seems to fluctuate over time. If there is any doubt about what Locke is saying, imagine if the 50p coin fluctuated in terms of the value of the pound. Today it might be worth 50p, but tomorrow it might be worth 49p. This is precisely the problem of the gold coin and silver coin example. What Locke is describing is the need for money to consist of units and tokens of those units that are both synchronically and diachronically stable. Synchronic stability means an absence or minimisation of arbitrage or risk-free profits. Diachronic stability means that the units, such as the dollar, persist through time. Diachronic stability differs from synchronic stability. The second goal of this chapter is to explicate this difference. Again, what we are after is the connection between how we establish reference frames and how we measure. I argue that synchronic fungibility is always relative to a frame of reference. This constitutes **FRIP.**

It is easy to recognize that some things are clearly not diachronically stable. We cannot use concert tickets as money units because they are not diachronically stable. At some point the concert ends and the ticket no longer represents the thing that is valued. This presents us with a puzzle. As stated before, money lacks diachronic fungibility: 50p today may be worth something other than 50p tomorrow. If it is not fungibility that is maintained, then something else must account for money's diachronic stability.

We can compare the choice of commodities such as silver and gold as monetary standards to Barrow's view that an equable motion must be chosen: 'We compare motions with one another by the use of time as an intermediary' (Barrow 2008, 37). Equable motions are much like silver or gold. In Locke's case, as covered in the last chapter, what makes the value of a metal, either silver or gold, unchanging is the conventional choice of it as the standard. In Chapter 2, we discussed the possibility of having two distinct measures for the passage of time: gravitational time and atomic time. Is this analogous to the choice between gold and silver standards? This again highlights a significant difference between how we treat the TRA and the MRA. We saw how an appeal to intrinsic value, as something independent of the functional exchange powers of the dollar, can be converted *mutatis mutandis* into an appeal for the pure passage of time. They play the same role in our conceptual schemata. The problem is that when we consider the purely arbitrary choice between gold and silver, it becomes difficult to think

of intrinsic value in the same way we think of the pure passage of time. It is implausible to consider all exchangeable value rates as supervening on intrinsic value. I am not saying that there aren't intrinsic values. But whether there are any or not, they play no role in the exchange practice except in limiting the scope of the exchange practice. Intrinsic values, such as the value that a human life has, are not commensurate: they can never even in principle be exchanged for something else. All exchange values are within the scope of the same array. This is precisely how the TRA leads us astray.

Ultimately the ability of silver to act as a measure depends on the perceived stability of its value. The stamp on a coin is merely the guarantee of the quantity of metal in the coin, as per metallism. This resembles the choice of a system of units for measuring distance. For example, I might pick up an arbitrary stick in a forest and use that as my gauge. I might also choose to measure distance with imperial rather than metric units. In spite of this similarity there is at least one important difference. Once gold no longer acts as a reference frame for fluctuations in value, then gold itself falls within the scope of things which may be valued in terms of the value of silver. If things are valued by silver, then Locke has an answer: 'An ounce of silver is always of equal value to an ounce of silver' (Locke 1824, 151). Nothing else would be fair.

Let us take stock of how this relates to time. Locke's claim resembles Maudlin's claim about a fair rate of exchange with respect to the dollar. More importantly we can compare this to Schutz's speed of light example in Chapter 2 (Maudlin 2002; Schutz 2022, 4). If we frame the speed of light (c) in the right way then we can say that then 'c is not merely 1, it is also dimensionless' (Schutz 2022). Just like as Maudlin describes, Locke would be shocked if, in exchange for his silver shilling coin, he received less than a shilling's worth of silver. Locke further acknowledges, particularly in the case of gold and silver, that we must choose which acts as a metre stick of worth and exchangeable value. The irony is that the opposite of the above situation in fact happened. Silver shillings that were freshly minted, shiny and new ended up being worth more than a shilling. Once we take into account Gresham's law, as we will do later in this chapter, we can start to appreciate the underlying problems any kind of money token faces. Moreover, we can begin to see why 'commodification' can fail to achieve the level of fungibility that currency demands. Where this is going is that there seems to be something over and above the

individuated dollar tokens that Price relies on for saying there is the dollar I give you and the dollar you give me.

Both silver and gold have this feature of being able to support a stable system of commercial measurement. Locke's preference was to use silver as the standard, simply because throughout history, silver coins in fact performed this function. Locke maintained that money throughout the 'civilised and trading world' is silver.[51] This was simply the metal, measured by quantity and purity. It therefore made no principled difference if the silver is coined or not, only a practical one: a proportion of light-weight coin can in practice circulate within a country above its true value, so long as it can readily be exchanged for full-weight coin (Shirras and Craig 1945, 225). However, as Chambers and Schumpeter claimed, money is alchemical: the noble metal of silver is by this process turned into money. This is why it is a mistake to confuse any particular token with the abstract measure. As Innes says, '[t]he eye has never seen, nor the hand touched a dollar' (Innes 2004, 155). We thus have to get to the bottom of this 'alchemical' process. In my view, it is the same process that turns a metre stick into a metre. We should therefore ask: has an eye ever seen, or a hand ever touched a metre?

What do we want from units of measure? We want measurement scales. We want to presume equality between intervals. This is all well and good if we have nondescript bullion. What if we put a stamp on it which witnesses the quality and weight of the bullion? I suggest that this distinction between stamped and unstamped bullion is significant. It not only makes one bullion bar distinguishable from another, but it affects the fungibility of the underlying metal in the two bars. We can now make a distinction between one and the other.

According to Aristotle, the original reason coins were stamped was convenience (Aristotle 2014b, 1257b1). All other valued things, such as the necessities of life, are not easily carried around, and so cannot be practical bearers of value. Instead, something intrinsically useful like grain but also portable, was chosen as money. Aristotle's examples here iron, silver and other metals. His account suggests that the point of stamping was to further commodify, even though stamping inhibits fungibility. Menger

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[51] Locke is using language that might be interpreted now as chauvinistic. It also suggests that those who use alternative representations of money, such as paper securities, are deviating from the civilized money practice.

calls this the 'organic' view (Menger 2009b, 38). Contrary to Ingham, he agrees with Aristotle that this process took place independent of a ruler, a sovereign or a sovereign state. At least insofar as the practice of weighing and stamping coins was the unintended result of innumerable efforts of economic agents pursuing their own interests, money is not the result of some socially teleological cause (Menger 2009a, 158). This is important, because if money comes about independently of some collective decision, then it seems reasonable to conclude that any collective intentionality bearing on the money practice is not merely an aggregate of individual intentional acts.[52] In the next chapter, I will make use of this view. The money practice, I contend, is a cross-cultural human universal across time and space. Money does not arise out of simple agreement. This will help us get a handle on the paradox described by Chambers. Money isn't what it seems, and second money depends on what it seems.

According to David Dick, teleological thinking can lead us astray in a few ways. One way is by convincing us that a thing ought to be used for what it was designed to do (Dick 2020).[53] We might think that it conforms to its telos to the extent that it serves the function for which it was designed. Money, as a social kind and as a technology, works well when it measures well.[54] (Or so I claim.) This seems to imply that, in our creation of money, we went out of our way to find something that measures exchangeable value well. Rather than being necessary to enable frequent exchange, money seems to have come about **because** of frequent exchange.

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[52] Brian Epstein makes such a distinction in *The Ant Trap*: group actions are not fully grounded by the actions of group members. In chapters 14 and 15 Epstein further claims that by extension, the intentions of a group are not fully grounded by the attitudes of its members (Epstein 2015).

[53] Dick's argument makes two important points. First, money can be only what is good at being money. Second, we incarnate money in the form that allows it to best achieve the task it is designed for. The big problem with this analysis is that 'the best achieves the task it is for' is not as obvious as a superficial analysis would suggest. Our individual intentions concerning money often do not track what is good at being money. It is instead our collective intentions that provide a selection mechanism.

[54] This measuring function is not categorical, just as the sharpest knife is not always the best knife to use. In the case of money, there are two distinct types of measuring problems, and two distinct types of errors. One type of error is deflation: the goods and services that are measured by money become less valued over time. The other type of error is inflation: goods and services become more valuable as measured by money over time. According to general economic consensus, deflation presents a far greater risk than inflation. The metallist will have us believe that deflation is a good thing. However, in both cases the accuracy of our increases or decreases relative to the extent of the inflation or deflation. If deflation is the riskier in terms of economic goals, then we would expect monetary policy to favour inflation over deflation if there was an equal risk of both. This, to my mind, is good empirical evidence of money's essential measurement role.

In order to illustrate the extent to which currency units have become fungible, consider an example proposed by Craig Warmke. Warmke asks us to imagine four separate bitcoin ledgers, A1, A2, A3 and A4. Consider what would happen if ledger A3 receives one bitcoin from ledger A1 and one bitcoin from ledger A2. There would now be two bitcoins in ledger A3. If the owner of A3 transfers those two bitcoins in one transaction to another ledger A4, there would then be two bitcoins in ledger A4. But this setup has strange consequences for the identity of the tokens. Warmke describes this as follows:

> The point is not that bitcoins are fictional and that fictions lack identity criteria. For the sake of argument, let's grant that bitcoin is fictional and that some fictional entities like Sherlock Holmes have identities within their fictional universes. The point is that the "two bitcoins" in A4 are not differentiated entities, even within any supposed fiction. At most, we have a quantity of a fictional substance that does not decompose into distinguishable individuals. An analogy may help. Suppose you deposit $1 from your friend and $1 from your sibling in your previously empty savings account. Asking which bitcoin in A4 came from A1 and which came from A2 is like asking which of the two dollars came from your friend and which came from your sibling. The question falsely presupposes that digital dollars carry this information on the bank's ledger. (Warmke 2022, 12)

This is why fungibility matters. Individual money tokens, particularly bank notes and coins, seem perfectly innocuous, metaphysically speaking. The main trouble, as I see it, lies in making the right sort of distinction between these money artefacts and the currencies that they represent. As Warmke describes above. With the example of Bitcoin, all that distinguishes one Bitcoin from any other is transaction history. The two remaining Bitcoin have identical histories. According to Warmke, "Given the transitivity of identity (i.e., if a = b, and b = c, then a = c), the "two" bitcoins would be identical and collapse into a single bitcoin. This conflicts with our initial supposition that the final address has two bitcoins (Warmke 2022, 6).

There seems to be an important difference between a unit of a currency (such as the bitcoin or the Dollar) and the currencies they instantiate or represent: each occupies a different level of abstraction. Units of currency are *tokens*, and currencies themselves are *types*. It is this level of abstraction that rebuts Price's claim about 'the dollar you give me and the dollar I give you'. It is thus not surprising that one-for-one exchange, whether in dollars or silver, is a recurring theme in the money practice. My contention is that the

Bitcoin above are instantiating what Price calls 'the very same thing' relation that measurement units have to each other.

As Aristotle claimed, coinage came about in order to further commodify weights of silver and gold. My claim is that ledger entries further 'commodify' in one sense. What we were after all along was what the process of commodification leads to and that is fungibility. Then again, even fungibility demands a further explanation. My explanation is impredicativity.

The practice of stamping made each coin fungible. Provided the coins in question have the same weight, and are stamped the same jurisdiction at the same time, this is unproblematic. But over time, rulers and authorities change. Coins wear. Owing to these changes, stamping coins can in some cases diminish their fungibility. The question that we should ask is why a system of units needs to be stable. In a system of fluctuating prices, a silver coin, which is worth 49p one day and 51p the next, is simply one more thing in flux. The metal seems not to give the desired stability to the currency in question. The answer, I think, involves what we expect measurements to be. Just as we expect no fluctuation in length measurements between my metre stick, my tape measure and my car's odometer, we want ostensibly equivalent money tokens to pick out the exact same abstract currency units with a high degree of consistency across space and time.

There is a synchronic monetary analogue to length and duration and that is exchangeable value. The most obvious conclusion about such exchange rates is that, at some level of analysis, each individual unit is treated as (at least contextually) indistinguishable from any other. A concrete token's 'suitability' is a function of its ability to represent the standard unit, which is abstract. Thus, to be money is to represent money. This bears on the question of time's flow because Price thinks that seconds bear the 'very same thing' relation to one another, but dollars do not. Chambers thinks otherwise, as do I. As we saw Chambers write, '[i]f I already have £5, why would I want to swap it for £5? What would that even mean?' (Chambers 2022, 71) Chambers, however, wrongly concludes that currency units bearing such a relation to themselves entails that they have no price or value.

As we saw in the introduction, Callender makes a similar claim: '[Money] is an invented placeholder for the things we value, not something we value in and of itself' (Callender 2010, 65). What I have argued so far is that money is a human universal in the

same sense in which our measuring practices are. We can use different units, such as metres or feet, to make measurements of length or distance. These units are necessarily arbitrary – we choose them by fiat. These correspond to the convention of currencies. While these are conventional, the money universal itself, which we measure using these currencies, does not seem to be subject to our will in the same way. For example, it is a presumption of our measurement practices that equal intervals in our units measure equal intervals of the relevant quantity.[55] This is not a coincidence. In just this way, money's ability to measure demands equality between intervals. In a system of units, the units are fungible.[56] This is part of what accounts for money's hypostasis. The gauges we use to measure are meant to correspond to unchanging units (Swinburne 1968, 73).[57] It is this feature that helps satisfy the second goal of this chapter and provides the correct interpretation of rates, through the use of **FRIP.** We may apply this principle to time because, as a measurement of duration, we consider each second as being equivalent to any other (hence Price's description 'very same thing').

 We find Aristotle writing that:

> This is why all things that are exchanged must be somehow commensurable. It is for this end that money has been introduced, and it becomes in a sense an intermediate; for it measures all things, and therefore the excess and the defect— how many shoes are equal to a house or to a given amount of food…All goods must therefore be measured by some one thing. (Aristotle 2014b, 1133a7)

 Callender appears to reason this way with respect to time: it allows us to know how a glacier relates to a baseball (Callender 2010, 65). What Aristotle does not say is that 'all things' must include money itself, since money is in fact exchanged for money. My claim here is that, to the extent that each instance of a particular currency unit is

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[55] This principle has some exceptions. The intervals in a logarithmic scale are not presumed to be equal. However, these sorts of scales are derived from linear scales that *do* presume equal intervals.

[56] 'A resource is fungible if you are indifferent to substituting one unit or fraction of a unit for another such quantity in a deal. In other words, all units of a fungible resource are indistinguishable and divisible. Furthermore, the resource must be such that more is always preferred to less, so that higher prospects in the preference list will correspond to more of the resource. In practice, it is difficult to think of a resource other than money that meets these requirements' (Edwards 2013, 37).

[57] According to Richard Swinburne, the unchangingness of the gauge is satisfied by the choice of a rigid rod. Standard rods are rigid bodies. Examples of units of distance include the standard metre and the standard yard. These are convertible into each other by multiplication or division by some constant multiple. We consider each standard rod in our measuring practice as being congruent with itself: 'We cannot measure it to show that it has not changed its length, for it is itself our standard of measurement' (Swinburne 1968, 73).

treated as equivalent to every other, the more money-like and reliable as a means of measurement that particular unit is. What makes currency *currency* is the fungibility of its units: the more fungible the more it conforms to the money universal. Fungibility satisfies the **IRP**.

One obvious problem to be addressed is that each physical token of a currency maintains some non-fungibility. In some relevant senses, a preference for one token over another is not unreasonable. If one demands a higher price for one 50p coin than for another simply because of this preference, this price may not be fair, but it does not follow that the demand is *unreasonable*. Maudlin argues, recall, that fair rates of exchange between the currencies has something to do with equality of purchasing power (Maudlin 2007, 112). There is a problem however: every transaction has some effect, perhaps small but not non-existent, on the entire system of exchange. This might well alter what a fair rate of exchange is.

What I have established in this section is that we can avoid Maudlin's need for fairness if, rather than focusing on the concrete tokens, we focus on the abstract currency. In one sense, Chambers is right: why would I swap £5 in one set of denominations for £5 in another? But in another he is wrong: I might well swap £5 for an amount of Dollars equivalent in purchasing power. We can get around the need for fairness in the same way as we deal with the non-fungibility of tokens. In the case of money, saying one dollar is worth one dollar merely describes the unity of the dollar.

We should note that there is a problem with this picture. The 'one dollar per one dollar' is relative to a specific origin that I describe as the 'zero-starting point'. This is a representational origin. Once such an origin is in place, other values of the dollar at other times can be obtained. An analogy to physics immediately suggests itself: the question of whether a second as measured in one frame is longer or shorter than a second measured in another frame is not an objective question. Instead, is a coordinate system-dependent question. This can be obscured by what we take to be extremely accurate measurements of proper time. If such problems arise in the context of measures of time, why should they not for specific currencies as well?

It is not too hard to imagine defeaters for the view that dollars are necessarily exchangeable in a one-to-one correspondence. In my view, there are two specific types of defeaters. The first is what I will call the diachronic defeater. In many societies,

charging interest is seen as immoral.[58] On some views, charging interest goes against the purpose of money. According to Aristotle, for example, money is not designed in order to make money. By making money from money, the lender is violating money's telos (Aristotle 2014b, 1258a39). They are using money unnaturally.

Now, it is all well and good to think that money should maintain at least some degree of diachronic fungibility, but it seems clear that there are goods and services available today that may not be available tomorrow. The rock concert I want to attend today will not take place tomorrow. There are also goods and services which may be available in the future but not today. The new guitar I ordered from a luthier will not be available until the artisan has constructed it. This diachronic defeater will be addressed in Chapter 6.

Recall: the second goal of this chapter is to give an account of how money's impredicativity works diachronically that can be used to generate an analogous account for time. This account is descriptive: I am looking at the way the money practice *does* work and not how it *should* work. It is clear that in at least some cases, currency tokens at one time are treated as fungible with distinct tokens at other times. Still, insofar as the dollar is not valued in a one-to-one correspondence in *some* cases, this constitutes a *prima facie* challenge to necessary fungibility.

At this stage, it is worth pointing out that, as the charging of interest rates or discount rates implies a temporal dimension of analysis, our use of money as a measure of value in these cases is diachronic. However, since this is part of the array of prices at any one time, it is also part of the synchronic analysis. In fact, I claim that such an evaluation is more properly thought of as synchronic. This is not the focus on my analysis at the moment, but for now, suffice it to say that a standard feature of money is the buying

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[58] One cross-cultural example is the Islamic prohibition of '*riba*'. Roughly speaking, '*riba*' means 'usury', but this is not an exact translation. The word can also refer more generally to any unjust, exploitative gains made in trade or business. There is some disagreement as to what precisely constitutes *riba*. The most widely agreed on type of *riba* is the interest or other increase on a loan of cash, known as *riba an-nasiya*. There is also *riba al-fadl* which refers to trading unequal quantities of commodities. These two types of *riba* are interesting because both are synchronic but the first one exploits over time, as is implied by interest rates, and the other is realised purely synchronically. Prohibitions on the charging of interest are very common cross-culturally. In 1275 Edward I prohibited the charging of interest and linked it to blasphemy (Spector 2005). In the 17th century, Pope Benedict XIV promulgated an encyclical, *Vix pervenit,* which prohibited charging even the smallest amount of interest (Schuck 1991).

and selling of itself into the future. Moreover, discount rates form the yield curves that I think demonstrate the dynamism of money.

The second type of defeaters is more difficult. They are purely synchronic examples of exchanging units of currency that are more or less than one-to-one. These sorts of transactions are very perplexing: why would anyone prefer to exchange for less than what they already had? I will consider three examples of such defeaters.

Synchronic Defeaters

Walter White

In the television series *Breaking Ba*d, the main protagonist, Walter White, manufacturers crystal meth. This is a lucrative – and very illegal – cash business. The result of carrying out his successful enterprise is that he has accumulated lots of bank notes. He can neither spend the money nor deposit it into bank accounts, as doing so will alert the authorities to his illegal activities. As a result, he simply stacks up the money and stores it in a hidden location. What he wants is to make the money 'legitimate' by money laundering: a scheme that will take his large sum of cash, which appears to be acquired illegitimately, and return a smaller sum, which appears legitimate. Walter White is willing to exchange one dollar for less than one dollar.

The Origami Dollar Bill Frog

In my local pub, there is a bar tender who can fold a dollar bill into an origami frog. Her trick has become very popular: pub patrons often search their homes for whatever dollar they have so that they can be folded into frogs. Suppose that I want my dollar folded first. I may offer her two dollars if she will just fold one of my dollar bills. I am therefore willing to exchange two dollars for one dollar.

Keep the Difference!

Imagine a situation in which you have a five-pound note and you want some pound coins. You ask a friend if they have any change. They happen to have only coins which add up to four pounds. Partly out of generosity and partly because of convenience, you offer your friend a five-pound note in exchange for those four pounds' worth of coins. This example demonstrates the point that Raven made earlier: while a one-to-one exchange

is the fair exchange, it is not difficult to imagine exchanges which are in some clear sense 'unfair'.

4.2 Gresham's Law

Let us recall what Price thinks is problematic about Mauldin's money example. He claims that there is the dollar you give me and the dollar I give you, as though the money practice consists solely of bare particulars which bear certain properties.[59] In this picture, there is no dollar *ante* rem, over and above its instantiation in individuals. Likewise, when it comes to 'the second' Price thinks that this measurement unit has the 'very same thing' relation to all other seconds. This leads us to ask what is the difference between one unit of measure and the other. A second as a unit is a standard of identity, i.e. something we treat as the same across instances.

This might well be apt in the case of physical currency tokens, such as bank note and coins. When applied to ledger entries and the idealised currency units, however, this analysis is inapt. Searle might very well be right when he claims that money must be realised in some physical form. But this physical form is not *presumed* by the practice itself. This is where Gresham's law is relevant: the individual properties had by any object which represents money get in the way of its ability to represent money. If one 50p coin has sufficiently many relevant features which single it out from other such coins, its efficacy as a unit of currency is greatly diminished. I will now demonstrate that Gresham's law constitutes a selection mechanism.

Money has many functions. According to broad consensus, the three traditional functions ascribed to money are as follows. Money is, first a medium of exchange; second, a unit of account; and third, a store of value (Chung 2009, 112; de Bruin et al. 2023; Hicks 1989, 42; Mankiw 2016; Mishkin and Serletis 2019, 49–51; Chambers 2023b, 2). So far, I have concentrated on measurement, which may be broadly construed as money's role as unit of account. Supposedly, a thing's being money should be positively correlated with its ability to perform these three functions: a thing that stores value,

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[59] I use bare particulars here for heuristic purposes only. I am not accusing Price of having such a view. The point I am making is that Price's employment of the phrase 'the dollar I give you and the dollar you give me' suggests that in his view that the money practice consists of a set of objects that can be individuated as particulars and have common enough properties that they count as a dollar.

enables and provides a medium of easy exchange, and accurately measures exchangeable value should be a paradigm case of money.

Unfortunately, things aren't that simple. These functions are sometimes mutually exclusive. Things that are the best stores of value are often ill-suited for being an accurate gauge of exchangeable value. The things that I think will appreciate over time will be the things that I am less willing to part with. Just as we would not want to use a fast watch as our time piece, what we use as money is not something we want to store away. Money is supposed to circulate. It is made up of currencies implying again some sort of flow. This flow is described as what Locke referred to as 'the vent' but now we would call it the velocity of money as it flows through an economy.[60] Money can also 'dry up' when scarce.

This brings us to the problem of Gresham's law: "bad money drives out good". The terms used may cause confusion. The 'good money' refers to currency tokens that have ancillary worth: they stand out in such a way as to elicit a perception of value over and above the value of the other tokens. Gresham's law presents a problem for defenders of the view that the intentional attitudes of a group agent supervene on the individual attitudes of group members. It would be easy to imagine everyone in a community wanting 'good money', perhaps even the best money. The problem is that all the precisely minted coins, containing the best ingredients, are *saved*, and the inferior coins are *spent*. Even though everyone wants good money, the good money is driven of circulation out by the non-attitudinal contributions of each member's incentivised actions. We can describe this as non-attitudinal because no one has the intentional attitude to drive out the good money. The reasons for Gresham's law is that the removal of good money supervenes on the contributions of individuals, but these individuals believe that they are conforming to the money practice. This is at the heart of my view: the measuring function of money arises because of selection mechanisms, like Gresham's law, that produce an abstraction that is useful for measuring exchangeable value.

The big problem with Gresham's law is that the units in one's system have varying significance. Put another way, one dollar may be more dollar-like than the other. Locke's

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[60] The velocity of money is the number of times one dollar is spent to buy goods and services per unit of time. If the velocity of money is increasing, then more transactions are occurring between individuals in an economy (Federal Reserve Bank of St. Louis, 2025). One might query why it is called the velocity of money and not the speed of money. The answers would seem to be that there is no spatial direction involved at all. There is only one dimension of analysis and that is time.

solution to bimetallism involved the claim that what is needed was very good money. On his view, money that accurately weighed in silver what the stamp claimed it weighed was good money. Whether this was his intention or not, this is an illustration of the view that what *should* be money is the thing that *functions best* as money.

It is worth examining some historical examples. In May 1695, in order to ameliorate the poor state of coins in England, the government of William III embarked on a recoinage.[61] It followed Locke's thesis and issued new full-weight coin. This ended in disaster. The problem is that the general preference of participants in an economy is to hold on to good money as long as possible and to spend bad money. As a result, all the nice shining new coins that accurately weighed their face value left circulation. What remained in circulation were those coins perceived as inferior. This should not have come as a surprise to anyone, but it does say something about what things in fact function as money.

Suppose that we uncover a hoard of Roman coins. We may all agree, from an examination of their stamp and size, that they are *Bona fide* coins, and will have no problem recognising these coins as money. (Perhaps some Roman equivalent of Walter White decided to store these coins in order not to alert the authorities.) This notwithstanding, the likely result of the find will be that the coins are put on display in a museum or collection. No one will think of taking them down to the shops to buy a pint of milk. There is a perfectly comprehensible sense in which they *are* money (they are coins), but in a more relevant sense, they are *not* money – there is not a collective intention to use them as money. They thus no longer function as money. This is very strange, and is a particular problem for the metallist account.

I think we must make a distinction between money *qua* artefact that is used as money and money *qua* the underlying abstraction these artefacts are meant to represent. This raises a question: when is a token a genuine money token, and when is it some residual artefact like the Roman coins? Answering this may not be as easy as we would

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[61] A good summary of the issues surrounding the recoinage is offered by Charles Larkin: 'The English Great Recoinage of 1696 was one of the great monetary events in history. The English currency, a bimetallic standard based on the weight and fineness of the coinage, was debased in order to pay troops in the Netherlands during the Nine Years War. By 1695 almost 50% of the specie content was missing from coinage in circulation, causing a monetary crisis. The May 1695 actions of demonetisation of England's debased coinage and the issuing of new full-weight coin were instrumental in the creation of the British Gold Standard' (Larkin 2014).

like. Sometimes when money is hoarded, the intent is to remove it from our common money practice. At other times, like when you lose money down the back of your favourite chair or in the pocket of a suit you no longer wear, this hoarding and removal is completely unintentional.

We must remember what we are looking for here: a response to the synchronic defeaters. My contention is that the distinction between currency units and the currency units' artefacts offers the right sort of reply. Furthermore, this reply supports the analogy to time as measured by seconds.

This is important for our purposes because measurement, which I think is the most fundamental function of money, depends on maximal fungibility. Artefacts, of any sort, act best as money when they are indistinguishable. Coins are minted to look indistinguishable; bank notes even more so. Ledger entries are more fungible still. Bitcoin entries, do not even have an individuated causal history. Just as a second is an abstract unit of duration that corresponds with some interval on a clock, measuring value requires an abstract unit of exchangeable value that has the right kind of correspondence to the things we use to measure exchangeable value.

In the previous chapter, I asked whether, when saying that one pound is worth one pound, we are comparing two things, such as physical objects. Are we comparing one individual coin to another very similar coin, or are we comparing that coin to some abstract thing called 'the pound?' In this chapter, I am claiming that we are *not* comparing two separate physical objects to each other. Instead, we are comparing one individual money token to an abstract object called 'the pound'. That abstract object, like the second, uses as stand-ins the units of measurement that the currency provides, and in keeping with this principle, each individual unit must support equality between intervals. This offers a reply to Chambers original challenge ('What is the price of $4?'): necessarily, in maintaining equality between intervals, the price is $4.

Three further, important distinctions are needed here, which correspond to Uskali Mäki's tripartite description of money: 'Money is an institutional universal instantiated in specific currencies and particular money tokens' (Mäki 2021, 2). The first thing distinguished, the money universal, is that which acts as money by measuring exchangeable value. Many currencies meet this criterion. Just as importantly, there were currencies that once functioned this way and then stopped. The second thing

distinguished is a base unit that supports equality between intervals. Each currency must have such a base unit. At this level of analysis, through our collective intentions, we make an abstraction. Examples of such an abstracted base unit include the dollar, the pound and the euro. The final thing distinguished is a tokening system, such as coins, bank notes and ledger entries. These things distinguished, we can then say that the Roman coins are money insofar as they are money tokens, but they no longer represent units of a currency. There is no abstract measure that supports equality of intervals. They are not being used to measure because they are not being exchanged. Some tokens being currency requires them being actively in circulation, and physical tokens are prone to being removed from circulation. Thus, the coins both are and are not money, but in different senses.

It goes without saying that money tokens can token currency. But money tokens often cease to token currency, and the circumstances in and process by means of which this happens is not entirely clear. A rather vague answer is the suggestion that when these tokens play a certain role in our money practice, they can be said to properly token currency. When they are taken out of circulation (buried in a hoard, lost down the sofa or in a suit pocket), or when they attain some other value that supersedes their role as tokens, they cease to token currency. Thus, when I find a bank note in a pocket of my suit, I can choose to add it to the other bank notes in my wallet, thereby making it money once again. When I spend that bank note, it has returned to the circulation system. I have added to the money supply.

So, given this analysis, what becomes of our three synchronic defeaters? The case of Walter White is not relevantly different from that of a Roman citizen who buries his coins in his garden in order to protect his wealth from some threat. These coins ceased to be in circulation. Were a Roman economist trying to figure out the total money supply in the economy, they would not count these coins. They would be noticeably missing.[62] A large-enough hoard of genuine money re-entering circulation could have just as deleterious a consequence to the money supply and the pricing systems as a significant

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[62] This is merely a hypothetical. I am not claiming that there were Roman economists in anything like our modern sense.

counterfeit supply entering circulation.[63] Each situation constitutes a serious threat to accurate measurement, and such situations are important for our overall view of money.

In the second defeater, my dollar bill is made to be distinct from other bills in such a way as to take it out of circulation. At some time, I might wish to unfold my frog and spend it like a Dollar bill, but so long as it is folded like a frog, the frog's symbolic value seems to make the token less money-like. In a sense, this is a form of alchemy: the bartender has successfully turned my money into a work of art.

In the third defeater, I am willing to exchange my five-pound note for only four individual one-pound coins. In this case, this is not obviously a monetary exchange, at least not merely. It might well be. Here the money tokens seem to fail the fungibility test. One question to keep in mind is whether the equivalence entailed by fungibility makes sense in regard to ledger exchanges. (I will circle back to the problem of these defeaters later in this chapter.)

How does this bear on our two goals? First: if money is merely a commodity like any other, then the **IRP** fails. As Chambers recognises, 'commodity theory of money offers an origin story in which a commodity of intrinsic value comes to be designated as money within a society. Money therefore has value directly because a commodity is money' (Chambers 2023b, 2). This theory bottoms out with intrinsic, non-relational value. In contrast to this, my **IRP** claims that some things may be valued relationally, but in relation to themselves. I have argued that evidence for self-reference can be found in the treatment of commodification as evidence for the function money is supposed to serve. Money units are fungible because money is a measurement practice, and maximal fungibility gives rise to impredicativity. My claim is that this measurement practice of money has implications for all measurement practices. However, the most important take-away from Gresham's law is that it constitutes a selection process which often defies individual intentions.

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[63] The introduction of gold from the Americas in the 16th century led to inflation, as the increased supply of gold affected prices and trade.

4.3 Money Units as Measurement Units

If the **FRIP** is correct, then Callender and Chambers are wrong. We do value money, at a rate of one unit per one unit. The goal of this section is to consider possible objections to the **FRIP**.

One objection is that, even if money is impredicative in certain circumstances, this simply be a cultural artifact. It is a phenomenon entirely localised to certain temporal and geographical regions and is therefore entirely contingent. It reflects nothing deep about the nature of reality.

Another objection, what I refer to as the Embedded Perspective View (EPV), will be examined in the next chapter.

Still another objection is that money can function many different ways. What I have cottoned on to is merely some contingent type of money practice. Thus, far from reflecting deep truths about the nature of measurement, this impredicativity does not ever reflect deep truths about *money.* In this section, I will argue that money seems to conform to a money universal, and that this conformity comes about as a result of measurement. This fits into the overall thesis: this money universal necessarily involves dynamic time, because at certain times certain evaluations are absolutely present, and there is continual change as to which ones are indeed present. This implies a money hypostasis.

In this section, I will need to motivate the view that the most fundamental function of money is to measure exchangeable value. Recall the standard view expressed above: money functions both as a medium of exchange, a unit of account, and a store of value. (Perhaps there are further functions, but they will not form any part of my argument.) These functions are important for my thesis, as they constrain both what can act as money and the further social constraints that we can place on money.

According to Uskali Mäki, 'economists hold rival views of the essence of money. They have different conceptions about which of money's functions are indeed the essential or intrinsic functions, and how the functions relate to one another, such as some of them being primary and others being derivative. This means economists entertain different real definitions of money' (Mäki 2021, 4). This is somewhat strange, as economics has as its object of study money, yet it seems to carry on very well without any

real definition of its object. This raises an important question: could other branches of science make the same move? Even though physics studies time, maybe it is not that well-suited to investigate its essential nature or ontology even though it is specifically a thing that it studies. Perhaps physics constrains how time is structured in order to make further investigations easier in much the same way that economists treat money.

What I have argued so far is that money demands a temporal place of evaluation. This is what I refer to as the 'zero-starting point'. A thing's exchangeable value depends on when an evaluation is made. This sounds very teleological. If money has a multiplicity of functions, then how societies value these distinct functions may be an entirely contingent matter. Money has been and continues to be used as a symbol of sovereignty(federations, nations, states or rulers), as well as a medium of political, cultural and artistic expression. Some bank notes (and not others) may be sought after for their beauty. This is all part of the conventionality of currency but is not core to its nature. Put in another way, what money is does not depend on its aesthetic qualities and is not grounded in its overt political messaging such as *"e pluribus unum"* or *"D. G. Rex F. D."*

On the standard view, when money deviates from these core functions it is less money-like. This is significant. There are times we do not treat money like money. For example, we sometimes imbue bank notes with symbolic meaning, such as when one has been folded into a frog. Function-talk produces a natural bias towards treating money teleologically. The traditional account holds that humans invented money in order to perform certain important social roles. The better it plays these roles, the better money it is. Thought of in this way, it would seem that money is a product of the composite of our individual intentions concerning exchange.

This yields a possible objection for my argument. If money were a result of a composite of individual intentions, then it would seem more likely that there would be a wide variety of money types, each designed for the function most called for by the individual intentions. Thought of in this way, impredicative money may have practical utility in one context or jurisdiction, but not in others. This impredicativity would then not be core to what makes money what it is.

Instead of being the result of some composition of individual intentions, it seems more likely (I argue) that money is the unintended consequence of trading practices.

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Frequent exchange realises dispositional powers, such as money's ability to measure exchangeable value synchronically. The content of these trading practices entail that impredicativity is baked into money. It also explains the high degree of homogeneity of the money practice over time and space.

I have claimed that money's essential function is as measurement or unit of account. But views differ on this point. For example, according to Walter Newlyn, '[t]he essential function, the performance of which enables us to identify money, is very simple: it is that of acting as a medium of exchange' (Newlyn 1971, 1). The exchange function is puzzling. Many things are used in exchange that we would not consider money, but the distinction between the two remains somewhat elusive.[64] For example, John Hicks points out that a standard of value is presupposed by the function of money as a medium of payment (Hicks 1989, 43). It is part of our practice to form a price list. Hicks (correctly) points out that even when money is not involved in exchange, as in many barter transactions, it provides price lists that make the transactions easier. Price lists are interesting because they represent hard evidence for the subjunctive, modal space in which money operates. This space is all about possible choices. The problem that I have being pointing to is that this presupposition goes against Pollexfen's '*certain, fixt and immutable'* claim that the money is a fixed scale, and that it is the fixed and rigid nature of this measure makes it reliable. I entirely reject this view. Instead, what makes money a reliable measure is its frequent exchange, and gives rise to its characterisation as a medium of exchange. Newlyn's argument has purchase because measuring things in monetary terms involves frequent exchange.

We are now in a position to compare some of what has been established so far to Chambers' claims. What I have established so far is:

1. Money is a measurement system (as implied by the phrase 'unit of account').
2. Money is impredicative: it has a price relative to itself.
3. Money is synchronically fungible. It does not matter where your dollar is.

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[64] A friend of mine from the small town of Ville-Marie in northern Quebec recounted to me the unique exchange practice in that region. According to his account, three items were frequently used in exchange: moose meat, marijuana, and maple syrup. This practice seemed to come about from a unique form of bartering: making a long trip into town just to get some money from an ATM seemed often too arduous and as a result these items were simply more convenient to use for exchange.

4. Money is not diachronically fungible. There is a discount practice. Hence the diachronic defeater.

5. Money is a human universal. Its essential features are not contingent. There is a money hypostasis.

I will now argue that money is an abstract object that can be studied empirically.

There are three dominant theories of money: commodity money, credit money, and fiat money. The distinction between these conflicting views of money is not hostile to the view of money as measurement which I defend here. Chambers' defence of the credit view, however, makes a few claims about the ontology of money. These claims offer a good starting point for addressing how we should conceptualise money. The first claim is that we can make a distinction between 'money stuff' and 'money'. This I agree with. However, according to Chambers, this distinction entails a further ontological claim. 'Money stuff' is an empirical entity. For Chambers, this 'money stuff' includes coins, bank notes, spreadsheet entries, ledgers of varying sorts and basically anything that can token or act as a symbol of credit – because, on Chambers' view, money is fundamentally credit. Conceptually and practically, 'money stuff' is nothing other than a claim of credit and debt (Chambers 2023a, 19). By contrast, Chambers says that '[m]oney is not a thing – not an empirical object of any sort. If we insist on defining money as a singular concrete entity, we will consistently and repeatedly misidentify money' (Chambers 2023a, 9). I agree that money is not a 'concrete' entity, but I claim that it is 'singular' in a robust sense. For Chambers, currency units are not singular entities. As he puts it, 'the dollar is not money but merely the name for one of many moneys of account' (Chambers 2023a, 26).

Rejecting the idea that the dollar is a 'singular' entity raises problems. One that stands out occurs in the trading practice of foreign exchange. We generally quote the exchange rate in singular terms: *the* dollar*, the* yen*, th*e euro. In doing so, we treat *the* dollar as an abstract object that can be traded for some other abstract object such as the pound or the euro.

Chambers says his way of thinking about money bears analogies to computer science and programming. Chambers argues that in computer science, there is a distinction between normal variables and pointer variables. Normal variables are locations in computer memory that can store a value, while pointer variables point to

normal variables and store no values themselves. According to the argument, money holds no value in and of itself:

> The value element of the money relation never lies in the money stuff, but rather can only be located across the entire money array. 'Array' denotes an ordered series, an arrangement of quantities or symbols, or, in mathematics, a matrix. (Chambers 2023b, 4)

Thinking of money in terms of an array does provide valuable insights. Money is liquid, easily exchanged for all kinds of things. It does seem plausible to think of all these things in terms of an array. I agree with Chambers that we must be careful to distinguish between tokens of money and some other aspect of money that is not what he calls 'money stuff'. That said, Chambers seems to overlook some problems. For example, on his view if we isolate 'money stuff', we do not find value in it (Chambers 2023b, 4). But this is strange. Obviously, a gold coin will have *some* value in isolation apart from acting as money. Chambers is careful in saying that what he calls 'money stuff' includes all the things that are a stand-in for money. These stand-ins for money always point beyond themselves. Chambers wants to argue that this stand-in relation that 'money stuff' has is to 'point' to two parties, the possessor as creditor and the debtor to which the claim is against (Chambers 2023a, 9). The has a dual existence in a sense, as money stuff and a gold object. But this gives us little insight into why this creditor–debtor relation is so liquid. Moreover, the creditor-debtor relation seems in my view to *reduce* the fungibility of money, yet the tokens, the 'money stuff', seem to *increase* its fungibility.

It is worth revisiting what Chambers thinks a 'dollar' is. On his view, it is not a thing at all:

> A dollar is not a thing. The 'thing' is a token of credit/debt denominated in dollars, and some tokens will be better than others - more stable, more liquid, or wielding more purchasing power - even if they have the exact same denomination. (Chambers 2023a, 118)

At face value, this would seem to vindicate Price's claim that all there is in an exchange is the dollar you give me and the dollar I give you. Again, imagine one's surprise at being told your 50p coin is only worth 49p today, and the day before it was worth 51p. But what is missing from Chambers' account is that the money array is a subjunctive array. It seems plausible that the idea of 'pointer variables' depends on how much an individual views the object in question in particular subjunctive terms. This, again, is why

the price list concept is so important. What is not accounted for by Chambers' view is why we should use money as a means of exchange at all, because it does not have the quality of being a pledge, rule and measure in dealings.

As with Newton's view, covered in the previous chapter, '[w]e value it [money] because with it we can purchase all sorts of commodities & money too' (Newton 1701). I believe this gives us a good picture of the array that Chambers describes. The problem with the normal/pointer distinction isn't in thinking of money as a pointer variable but rather in isolating what exactly we could mean by a normal variable.

In most commercial activity, the value of things is often expressed as symbols which express its capacity for acquiring 'all sorts of other commodities & money too'. For example, a farmer does not view the wheat that he grows in terms of the bread he will make to feed his family, but rather in terms of the entire array of its economic capacities. This array includes money. In other words, *the money array* includes money. My contention is that most things in that money array will be pointer variables, rather than not normal variables. The gold coin illustrates this. The moneyness of the coin *points* to the array, but the coin itself *qua* gold object apart from money is a *value* in the array. The gold coin is both a normal variable and a pointer variable. In my view, concept of the money array is rather more useful than the normal/pointer variable distinction. It seems plausible that when we talk about the abstract object 'the dollar', we are actually talking about the dollar *array*. Certainly, this is abstract and singular and impredicative, but, contra Chambers, it does seem to be something that could be studied empirically.

So far, Chambers' model consists of two sorts of things. First, there is money, which is not a 'thing' as such but a rather stand in for a relation. The view is not that money *depends* on social relations, but rather money *is* a social relation. Where I think Chambers is right is in noting that money seems to perform a function without any individual intending for it to perform that function. This explains why the credit/debtor relation is often not clear in our everyday use of money. As Chambers claims, 'money is always social, and always relational, because it always involves two parties and a relation to the future' (Chambers 2006, 3). It should come as no surprise that I completely agree: money is a relation to the future. Money loses all ability to measure exchangeable value with the past. The problem with the view expressed here seems to be that there is not a

clear distinction between various currencies, what Chambers refers to as 'moneys of account'.

Uskali Mäki makes a similar distinction between tokening of money and money itself as a human kind. Mäki offers a more plausible distinction: 'Money is an institutional universal instantiated in specific currencies and particular money tokens' (Mäki 2021, 2). Here we see a tripartite division in the money practice. This division, I contend, is why this human universal seems rather opaque and also homogenous. It is also the basis for much confusion, as it is easy to conflate these three aspects. This tripartite distinction will help to identify what part or feature of a currency system needs to be fungible.

I should at this point clarify that I do not think money is a necessary feature of societies. We can imagine a society that has no need for money. We can also imagine a society that has no need for clocks. The Earth's orbit around the sun happened long before humans started to use this orbit as a clock. It is only when there is a need to measure things people trade that money comes into existence. In addition, it is this distinction that will isolate what aspect of the money practice applies to the MRA.

Sgambati's approach is helpful:

...money does not simply denote a metrological system for the accounting of debts and the scaling of prices but, more importantly, it also connotes a process of signification/valorisation in which values are constantly and contextually becoming and mutating in the name of money... (Sgambati 2015, 313)

In this thesis, I defend a similar approach. Money depends on a temporal asymmetry whereby it prices for things in the future but is unable to trade with the past. Again, this is how money manifests modal considerations as implied by the word 'can'. The money practice consists of things in flux, and it is because of what Sgambati describes as the Janus-faced nature of money that it both measures and is measured. In contrast to Pollexfen's conception of money as 'certain, fixt and immutable', it is in flux because the things it measures are in flux. This is the **IRP**.

I contend that we can apply the same sort of reasoning to time. There are, of course, alternative rates for the passage of time, because all the things that are measured by time are in flux. Time, like money, has a Janus-faced nature. As Barrow claimed, 'time implies motion to be measurable; without motion we could not perceive the passage of

time' (Barrow 2008, 35). We measure time with motions, and we measure motions with time. Time always involves two directions of fit.

Money depends on what I earlier called dispositional powers. These have modal features, and are what Benjamin Anderson refers to as the 'Bearer of options' (Anderson 1917, 425). If I imagined a 'definite contingency' and I wanted to preserve my ability to acquire it, then I would acquire what I think are productive assets. On the other hand, what money seems to represent is immediate liquidity. What immediate liquidity represents is the ability to pay immediately for different sorts of things. These abilities are, of course, in a strong sense modal. In my view for these powers to exist, they must be exercised. A currency's dispositional powers are realised through frequent exchange. This frequent exchange constitutes measurement, and therefore constitutes the essence of money. This is why one cannot separate the measure from the 'medium of exchange'. It would be like separating measurement from the act of using a measure.

This pattern of exchange constitutes diachronic facts about money. Once exchange has taken place, these facts are in the past. They become ephemeral as they lose assurance that our measurements are accurate. Each new exchange is in some degree a reassurance that the future will be like the past but still there is a difference between the potential of I could get all kinds of things simply because there are modal considerations that no longer exist in the past. Money as currency is inextricably linked to circulation. Frequent transactions and frequent circulation provide that reassurance.

In the dispute between Maudlin and Price, Maudlin asks: 'What, then, is a fair rate of exchange of dollars for dollars? Obviously, and necessarily, and *a priori*, one dollar per dollar' (Maudlin 2007, 112). If this is a synchronic evaluation at τ_0, say, then this seems necessarily true. However, when we talk about the value of the dollar for settlement at *different* times, this is neither a necessary nor an *a priori* truth.

So much for fair exchange rates; how about unfair ones? Here is an objection raised by Michael Raven:

> Even if fair currency exchanges are necessarily at the rate of 1 unit of current per unit of that same currency, there can be unfair exchanges. This can happen in many ways: the rate of exchange could be 1.06 units of currency per unit of that same currency, or 5 units, or 0.75 units, etc. A consequence of this is that there is no rate such that every unfair exchange is an exchange of that rate. But the distinction between fair and unfair rates of exchange has no analogue vis-à vis the rate of time's

passage. So, necessarily, $1/$1 is the only fair rate of exchange for the dollar. This is a coherent rate; it is a coherent rate that is fixed of necessity. (Raven 2011, 9)

Raven's objection exploits a flaw in Maudlin's formulation, namely, that the distinction is based on 'a fair rate of exchange'. One describes markets using many adjectives – efficient, competitive, and so on – but are markets *fair*? When certain conditions are met such as when participants have access to perfect, transparent, and costless information, the transactions can be described as efficient, but this is importantly distinct from fairness. Since the conditions stipulated in this analysis may seem farfetched, some philosophers have even claimed that markets are intrinsically unjust (Kirzner 2002, 210; Marx 1986; Wertheimer 1996, 232). This intrinsic injustice suggests that unfair exchange is far more likely. But, since my goal is to give an account of money in impredicative terms, the account I offer does not need to take a stand on the possibility of just or fair markets.

According to Maudlin, the 'one dollar per one dollar' exchange rate reflects a fair valuation based on purchasing power parity. This seems to miss something fundamental about our money practice. Purchasing power is a function of the entire array, which includes the dollar itself. The dollar is defined in such a way that it is not identical to something that has the same purchasing power. This will become clear when we consider alternative currencies that exchange at parity in Chapter 6. What is of interest to us at this point is how the indiscernibility of identicals and the general ontology of abstract objects bears on our analysis. Money is viewed as having two apparently contradictory properties. Sgambati, for example, claims that participants in the money practice are capable of grasping money as both universal and particular at the very same time (Sgambati 2015, 314). Price's account leaves this aspect out. As we noted in our discussion of bitcoin, there is no *particular* bitcoin. This suggests that money *qua* money is distinct from its tokens. It is abstract, conceptual, performative. This means that the dollar *simpliciter* is substitutive and non-localised, which has significant implications for its identity conditions. I think we can dispense with 'a fair rate of exchange' distinction all together. Instead, what I will argue is that we are talking about identity and not fair value. Synchronically speaking, saying that $1 is worth $2 is like saying that I am twice as tall as myself.

On the other hand, there is nothing unfair about an exchange rate of 1.06 units of currency per unit of that same currency if that exchange is seemingly diachronic. There are lots of trades in which the dollar is exchanged with rates other than 'one unit per one unit' so long as this exchange involves a significant duration. This is what produces the diachronic defeater. We will later encounter all kinds of market trades that are just like this. Raven's and Price's objections rest on whether the dollar I give you and the dollar you give me are different things. This bears a perfectly reasonable analogy to time. When a clock runs fast or slow, the comparative seconds are analogous to tokens not both being treated as identical to the dollar. In other words, as I have been saying, fair and unfair rate of exchange is a red herring.

At this point we should summarise how this section has advanced my two goals for this chapter. First, I have homed in on individual currency units and by doing so separated them from the tokens of currency units. My contention is that individual currency units are necessarily impredicative. (This is also why Price's response to Maudlin does not work.) This supports the first goal and more clearly delineates which thing I am calling impredicative. It is not the money universal, and it is not money tokens. Instead, it is the currency units. But this argument is vulnerable to functional objections. If money has other functions, this measurement abstraction can be challenged. In this vein, in this section I have also argued that, since money is a measurement and measurement units are abstract, we can make the further claim that currency units are self-pricing.

The money practice involves trading, where the dollar now is used to buy the dollar in the future. This practice has lots of volume – in other words, lots of trades. There seems to be a limit, however, that is constitutive of what I have called the 'zero starting point'. As we saw Chambers rightly point out, we do look with puzzlement when we look at the £5 note and ask, 'why would I want to swap it for £5?' (Chambers 2022, 71) My argument is that this starts to make sense once we introduce a temporal axis, but trades must be able to take place at the origin of this axis. Part of what this means is that we can construct a monetary reference frame. This sets us up for the second goal of robustly applying monetary impredicativity to time.

As we covered in our discussion of Mäki's tripartite description, we need to distinguish very carefully whether in talking of money we are talking about the human

universal, an individual currency, or the physical objects that we take to be money. Confusing these levels of analysis is a significant reason for Price-style claims that there are two distinct things being analysed (Price 2011b, 304; Robinson Erhardt 2023). I am arguing that like 'the second', when we talk about 'the dollar you give me and the dollar I give you' we are talking about the 'very same thing'.

At this point the problem is one of maintaining this money practice. According to Mäki, too large and too complex a system would have to disappear before money could disappear: 'Money as a social universal is far more robust than currencies and specific monetary institutions' (Mäki 2021, 17). This robustness (what I have called money hypostasis) suggests that we should think of money the same way we think about our other measurement practices. Inches, centimetres and cubits all measure, and are distinct from, length. We can conceptually separate measurement units from what they are supposed to measure.

What money demands is fungibility, and if our money is based on both a silver and a gold standard the gold redeemable from some amount of currency will not be fungible with the silver redeemable for that same amount. The advantage produced here is not ease of exchange but rather ease of measurement. However, as I just claimed earlier, when we look at currency units diachronically, every point of analysis, every 'zero-starting point' has its own set of the things it can be exchanged for. Along this axis, dollars are not fungible. What I am arguing is that the identity, the value of and the fungibility of our measurement units are relative to a frame of reference, as is the 'zero-starting point'. This is precisely how rates should be interpreted, and this supports the **FRIP.**

4.4 The Synchronic and Diachronic Distinction

In this section, I will advance my second goal by building on the notion that currency units are worth different amounts over time. We seem to have fungibility insofar as and to the extent that we are puzzled as to what it could mean to ask, 'why would I want to swap £5 for £5'. The puzzle arises because at that point the units are maximally fungible. No amount of trading can change this exchange rate. However, this starts to make sense once we introduce a temporal axis for discounting. On such an axis, one has synchronic maximal fungibility only at the 'zero-starting point'. The further away from this point you get, the more the currency unit will be subject to discounting. However, there is only one

direction in which we can look away from this starting point: into the future. We cannot value, in this sense, into the past. I will argue in this section that the synchronic/diachronic distinction can deal with this phenomenon. More importantly, particularly in Chapter 6, it is this similarity to time that will suggest a sort of dynamism.

In the introduction of this chapter, I claimed that our money contains a synchronic analogue to length and duration. In this section, I will more fully explain just what this entails. The synchronic and diachronic distinction has its origin in linguistics, and was first introduced by Ferdinand de Saussure (2011). Language is analogous *qua* as a social or human kind to money. A synchronic analysis of language deals with the state of a language and the linguistic community at a particular point in time. It is studied as a fixed phenomenon existing at a given moment. This reflects the assumption that the synchronic system is static: there is not any duration for change to occur. By contrast, the diachronic system is dynamic: there is duration over which change can occur. I want stress that the change I am referring to in this context is the sort of change that those with B-theoretic deflationary sympathies are comfortable with. Here is a good example of why the McTchange distinction is helpful.

Diachronic analysis can represent the evolution of the system over time. There is an implicit assumption that it is possible to study language usage without reflecting on changes in this usage over time. We can synchronically analyse how grammatical tense works, and in this respect, there is still what we can call a temporal horizon.[65] The goal of this section, and the second goal of this chapter, is to explain this synchronic temporal horizon. Much like a perspective tied to a particular location, there is also a temporal perspective that is tied to the time of evaluation.

Let's return to the ice hockey example covered in Chapter 1. If I say that there are 10 minutes left in the game, such a statement is synchronic with there being 10 minutes left on the clock –that is, it takes place at the moment where there are only 10 minutes left. It also is synchronic with the protentive anticipation of the end of the game. There is

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[65] The horizon of temporality can refer to the distance in time over which events can influence behaviour, or to the idea that time allows us to understand being. Humans for example have a finite life span. We also make agreements that have durations. If I take out a 25-year mortgage, then this agreement has a horizon of 25 years. As time passes and the time to maturity reduces then the temporal horizon also reduces. If we analyse events, we do not have a dropping off of the horizon *per se*. However, the 'causal influence' of any event is constrained by a light cone structure because, according to relativity theory, there can be no causal influence that propagates faster than the speed of light.

a perspectival urgency. This is different from saying that the game ended 10 minutes ago. When there are 10 minutes *left*, the players are very concerned about those remaining minutes, and they hardly think at all about the previous minutes that have passed. Strangely enough, once the game is over, the minutes making up the game can become more worthy of our attention, as we discuss the highs and the lows of the game once we are at the pub. This asymmetry requires an explanation. What we appreciate in our post-game analysis is that we can look at the entire evolution of the game, and these facts remain the same regardless of our temporal distance from the game itself. We can say that such-and-such a play was a 'turning point' in the entire game.

We have the same sort of way of analysing money. Looking towards past prices, can help us understand how we got to where we are, but it does not have the protentive anticipation that future prices have. Currency units are relational: we can understand that the dollar is worth a dollar whenever there is an opportunity to exchange it for a dollar. Currency units also dispositional. These dispositions have the form 'it is possible for me to pay for all kinds of things' if I were to offer this dollar to someone with commodity x, I would thereby obtain commodity x'. The money practice depends on this subjunctive and counterfactual stance towards currency units.

At any time, our dispositions are oriented towards the future. This is what Paul Horwich referred to as the decision asymmetry. We act for the sake of the future not the past. The unity of the dollar in a temporal sense coincides with the limits of our causal influence. According to Horwich 'It is rational to act only for the sake of things we might cause to occur and we are well aware that events , including our own actions, can exhibit causal influence only over the future' (Horwich 1987, 10). What goes hand in hand with the decision asymmetry is what Horwich calls the knowledge asymmetry. If we knew the final score in the ice hockey game, then the urgency required to play the game would diminish. Yet without the urgency, the results of the game are likely to be different. Knowledge affects our decisions. Information impacts utilisation.

Predictions of the future are simply different kinds of beliefs than those about the past. Callender thinks some temporal asymmetries can be explained away anthropologically. The *explanans* are not to be found in metaphysics:

> The knowledge asymmetry and the causal-counterfactual asymmetry, have a
> powerful effect on creatures in our world. They entail that creatures like us will be

very uncertain about later events on their worldlines even though they tend to have some measure of control over these events. (Callender 2017, 259)

The past is epistemically more accessible. As Callender rightly points out, even when we have control over certain events in the future, we still think of them as open and indeterminate. For past events there are many sources of evidence, such as memory. We believe in our past experiences. Just as importantly, we think in terms of cause and effect, and we often do this in counterfactual terms: if a cause had not happened the effect would not have happened. In this section, I will make a distinction about past counterfactuals as compared to present counterfactuals.

One important goal of this section is to fully account for the synchronic function and behaviour of money. The typical way this is framed is: a synchronic analysis is an analysis across a particular time slice. (This is analogous to a foliation of spacetime.) In contrast, a diachronic analysis of a system analyses how it changes over time. This 'over time' can be represented along a temporal axis. A synchronic account should not make use of a temporal axis. It is this latter assumption that I intend to challenge. Implicit in a synchronic account is the various dispositions towards the dollar that exist at any particular time. It is a snapshot. But snapshots require a duration, however brief, for the exposure. They can represent statically things that are changing and moving. A synchronic account of the dollar should be given in terms of its dispositions at a particular moment. However, what I will argue is that it matters whether that moment is actually present when evaluated.

Any synchronic account of a language will have different horizons of temporality depending on whether the time slice being analysed is present in time or not. If we think of these snapshots as foliations, this amounts to choosing some preferred foliation. A synchronic account of a time that is present differs from a synchronic account of one that is not present. Different modal facts obtain at each.

The point I am making is that any synchronic analysis of a language must include an analysis of all counterfactual expressions concerning possible future situations. This does not involve an ontological commitment to an absolute present. That is not the point. Rather, this sort of linguistic analysis is constrained by the knowledge we have and the causal counterfactual asymmetry that constrains creatures like us. Similarly, yield

curves face representational limits for states before the zero starting point. The possibilities for future evolution are too vast and inaccurate to have any purchase on the discipline even still all these predictions exist at a synchronic point in time. The zero starting point represents an equal and opposite analytic barrier. All such counterfactual speculation is like the yield curve both synchronic and diachronic.

Consider the diachronic features of the word 'bachelor'. At one time, the word meant 'unmarried man'. This synonymy relation made it at one time, a potential good example for Quine to use in his criticism of the analytic/synthetic distinction (Quine 1951). Many words held similar potential, yet it is only the word 'bachelor' whose potential to feature in an illustration of this distinction is actualised by Quine. A diachronic analysis is not at all concerned with these modal facts. Likewise, the word 'bachelor', because it means 'unmarried man', was a good title for a reality television show. Again, there was a potential for other words to be used as the title of the game show. Once 'bachelor' is used for the title, modal facts concerning the other potential titles simply drop away, and the *explanans* for the suitability of 'bachelor' as a title involves the actual evolution of the word rather than any counterfactual analysis.

In the case of language, these modal facts are hidden because the temporal horizon faces towards the past. They lack salience. This explanation is opposed by opponents of flowing time. Craig Callender, for instance, thinks that the direction of one's temporal horizon of analysis should not matter:

> To me, the lesson of the foregoing considerations is that metaphysically speaking, as it were, one can get robust counterfactual dependencies in all directions, null, timelike, and spacelike. The world doesn't "unfold" along the time direction as the tenser hopes, at least not in any way suggested by the physics. (Callender 2017, 179)

The money example demonstrates a profound difference that is temporally directed. Looking towards the past alters what is salient. Money demonstrates a commitment to unfolding along the time direction and it is this unfolding that is the primary interest of this thesis. This counterfactual dependency runs in one direction and makes reference to a unique present at all times. There is an important caveat here, however: both language and money are human kinds. Those with deflationary sympathies, such as Callender, will tend to dismiss appeals to anything but physics. If

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value depends on our dispositions, then if the bearers of those dispositions go out of existence (with, for example, the extinction of the human species), a unit of currency is no longer a unit of measure. The next chapter will deal with EPV, which claims that we can distinguish epistemic needs from an underlying commitment to any metaphysical picture. Part of my thesis involves opposing this move. However, at this point, our concern is with the way money in time works.

Callender claims that we should get robust counterfactual dependency in all directions. But this reintroduction of counterfactual dependence does not come without cost. Callender thinks some temporal asymmetries can be explained *away* anthropologically rather than explained metaphysically. As he rightly points out, even when we have no control over certain events in the future, we still think of them as open and indeterminate. This accounts for why the 10 minutes remaining in the hockey game example so captures our attention. Moreover, as David Mellor argues, we owe this attitudinal disposition to evolutionary adaptation: 'In order to survive in our world we need the default habit of believing that what we see happening is happening now' (Mellor 2001, 57).

The synchronic analysis also presupposes that a language can be given in its totality at a time. We can think of a snapshot of the language practice like a mathematical function: any change in any of its parts implies a change made to the function as a totality[66]. Unlike sanitation, money is maintained by systems of practices and institutions that are themselves difficult to figure out. Their synchronic and diachronic features are interwoven and in many cases opaque. Synchronic and diachronic are often used as contrasts but this is too simplistic. In the case of money, our past-directed monetary attitudes fit well with the linguistic sense of diachronic, but our future-directed ones seem better suited to a synchronic analysis:

> The opposition between synchrony and diachrony was an opposition between the concept of system and the concept of evolution; thus it loses its importance in principle as soon as we recognize that every system necessarily exists as an

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[66] The synchronic perspective applied to language is like the web of belief proposed by Quine. If we could take a snapshot of all our beliefs, they would form an interwoven tapestry. According to his account, change one belief and there is a need to readjust other beliefs. Change some of our more basic and fundamental beliefs one must make readjustments throughout the entire web Synchronically, we could analyze the totality and interconnectivity of all these propositions. A diachronic analysis would, in contrast allow for changes in time (Quine 1951, 34).

evolution, whereas, on the other hand, evolution is inescapably of a systemic nature. (Jakobson et al. 1980)

In the case of money, the evolution of prices constitutes the diachronic facts that maintain any system of prices at any time. Money's causal powers are evaluated moment by moment. They necessarily have a historical, evolving, diachronic component, but as the above passage illustrates, at every moment they have potential, non-actualised features as well.

If we consider money as a system, its past and future are inseparable structural elements. Prices reflect their past evolution but also the possibility of further development and change. These dispositional facts exist as though they were fixed to a static background described often in intrinsic terms. There is an anticipation of a further future evolution that are part of any moments pricing system and structure. According to Sgambati, we should differentiate between 'counting' in the sense of ledger entry facts at any time and 'calculability', which consists in projecting those facts along a temporal horizon:

> Yet, as I have argued, "calculability in money terms" does not simply involve "countability" *sensu strictu*, that is, a synchronic calculation based on the book-keeping of debts and the scaling of prices that are already given in relation to a money of account. Rather, it primarily involves discounting, a diachronic calculation of the present price of an asset in relation to its future value, as against a background of potential (market) opportunities. (Sgambati 2015)

Sgambati has identified something important here, what is often referred to as 'the money of account'. This score-keeping function of money does not, however, exhaust its role as a measurement. The money of account function that keeps score so to speak, isn't the entirety of money's measuring function. There is a form of future pricing which we may call 'discounting'. What is problematic however is that these calculable future prices do not actually represent an evolution over time. At any time, diachronic calculations are part of any synchronic pricing structure. Sgambati refers to these calculations as diachronic, but they are not. All such calculations constitute, at the moment of evaluation, one system of prices in relation to one 'zero-starting point'. Just as in the 'bachelor' example, there are possibilities that cannot accounted for in a diachronic analysis, because they are not actualised. There are no ledger entries, no transactions.

A useful way to differentiate the discounting practice from the book-keeping practice is to introduce a new term, 'synchronic-diachronic'. This represents the total possibilities for further evolution obtaining at any moment. For example, a synchronic analysis of a currency will tell us the state of its price system at a particular time. At any particular time, one dollar will be worth one dollar. This sounds simple and clear-cut, and indeed very much like an array. However, each price system will also include what appear to be diachronic elements, such as loans and contract completions. Any time that a synchronic account requires a temporal axis then it should be referred to as 'synchronic-diachronic'. It is this connection that leads Newton to recognise that if you change the expectations of interest rates, you change the price of property (Newton 1701).

I contend the currency units themselves are self-referential, or impredicative. For example, the synchronic analysis of the dollar involves the *a priori* claim that it is worth one dollar. This is only given meaning by an actual exchange, when you actually trade that dollar for a dollar. It is worth a dollar in the context in which there is a standing possibility of paying for something. It also includes the seemingly diachronic claim that the dollar can purchase itself at different times in the future. This generates a yield curve. Both of these evaluations can be found in the same process and at the same time – namely, in the present. This raises serious questions as to whether any future valuing can be treated as diachronic. My claim is that they cannot. This is the key feature which differentiates money from language. In linguistics, evolution over time as applied to future states of affairs, just doesn't arise.

On this point, Sgambati is critical of Ingham's account. According to Sgambati, focusing on discounting shifts the attention from those who allegedly 'count' to those who actually 'make' money. For discounting does not measure value properly speaking. Instead, it brings value into being in the form of 'purchasing power'. '*Purchasing power*' is a potential power. It exists because there is an array of possibilities, much like those that exist in biological evolution. If we recall, the main claim that Maudlin's 'one dollar per one dollar' account relies on is the concept of an equality of 'purchasing power' and only a fair rate of exchange gives us an equality of 'purchasing power' (Maudlin 2002, 262). This fairness of purchasing power seems to be a fixed, synchronic notion at any time of evaluation. One important component of Sgambati's argument is that 'purchasing power' is not merely the power to purchase as in pay and exchange but also it materialises an

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absence. It is the power *not* to pay and exchange (Keynes 2018b; Sgambati 2015, 315). This somewhat complicates Maudlin's assertion about fairness. We only know that an exchange is 'fair' by means of the measure that is money, but this judgement of fairness is actualised partially by the power not to exchange. Refusal to exchange two items of supposedly equal purchasing power would not seem fair.

To illustrate this, consider species evolution. A certain population of a particular species of even-toed ungulates at one time had the possibility to evolve into whales. Perhaps if they hadn't evolved that way, a population of odd-toed ungulates might have exploited that niche. Perhaps that population of even-toed ungulates also had the potential to evolve into other kinds of organisms. These other potential organisms do not fit into the diachronic analysis because they were not in fact actualised. This, I claim, is much like a total system of prices. Only some prices result in transactions that are accounted for. Potential future values are part of the synchronic facts at any time slice for the purposes of analysis. In the case of the dollar, the 'one dollar per one dollar' rate of exchange is dimensionless. However, if we introduce a future temporal axis, at any time the value of dollars *vis-à-vis* dollars is still dimensionless. However, like Skow's claims covered in Chapter 1, the value of dollars *vis-à-vis* dollars and duration has dimensionality at any time.

What we can take away from this section is that discounting plays a significant role in realising purchasing power. This is not merely a set or array of prices, but the standing possibility of acquiring or not acquiring various goods and services. This characterisation applies to money itself. The concept of purchasing power has modal content which extends beyond the mere records of past transactions. The discounting practice involves a present valuing of future possibilities. This requires representations with temporal axes, but this is not a representation of the evolution of the value of money extending into the future. Rather, it is a *synchronic* pricing relative to a 'zero-starting point'. Where there is zero discounting, the dollar is exchangeable for a dollar, and the frequency or infrequency of exchange becomes immaterial (no exchange changes the value of any dollar). This again points to the maximally fungible unity of the dollar. This '*zero-starting point*' is absolutely required for monetary measurement.

4.5 Conclusion

In previous chapters, we constructed the TRA in order to then construct the MRA. The point of the former was to demonstrate that the flow of time cannot be expressible as a rate. In this chapter, I argued that there appears to be a problem with the MRA. My first goal was to show that, given the specific regress features of the MRA, impredicative rates appear to solve that alleged problem. My second goal was to apply the same reasoning to time. My claim here is that these features of money show us where to locate the dynamism of time. The problem is that the TRA has an enthymeme. There is a hidden premise that any another time scale must be another dimension of extension. I have fleshed this out by distinguishing between **TRA P4** – which I accept – and **TRA P4*** – which I reject. I have also argued that if we allow for impredicative rates, the regress is non-vicious. This furthers my second goal: just as we do not need super-money nor meta-money to stop the regress, we do not need super-time nor meta-time. In Chapter 5, we will see explicit examples of how to introduce such time scales without this ontological regress.

In the first section, we observed that there is something unique about measurement units. They are abstract, fungible, and interchangeable. This is why Price claims that the second is the 'very same thing' each time it appears in the purported rate. We also covered Chambers' argument that money has no value. This appears to follow exactly the same pattern of reasoning as Price's argument, and seems to fail for the same reasons. First, it seems odd to suggest, as the argument does, that money does not self-price. As Chambers illustrates, perhaps unintentionally, the price of a £5 pound note (£5) is explicitly displayed on the self-same note. Without this self-pricing feature, we couldn't engage sensibly in any kind of discounting, something we appear to do without trouble all the time. Another way the argument may be resisted is to insists that a statement's being tautological does not make it senseless. I agree that the price of a £5 note being £5 is tautological in some sense but, to use Russell's distinction, it is not a barren tautology: it has practical uses. We can use it to make sense of our discounting practice. We can use it to generate yield curves. From this starting point we can obtain the present price of future money. Therefore, yield curves are a unique example of an analysis that is both synchronic and diachronic. We need a further distinction that is the synchronic/diachronic.

The selection process by which money comes into existence involves first commodification and then fungibility, until we achieve maximum fungibility – that is, a sort of identity. This identity relationship always makes reference to a 'zero starting point.' Therefore, the price of the dollar is a dollar. This impredicativity is pervasive throughout the entire money practice. Because money is impredicative, fungible and interchangeable, it must be abstract. A currency consisting solely of non-fungible tokening cannot perform functions which are essential to currency. As Innes correctly observes 'The eye has never seen, nor the hand touched a dollar' (Innes 2004, 155).

We saw that there are problems with Chambers' argument, insofar as it seems to involve an appeal to valuing external to the money practice. However, if money is a means of measuring exchangeable value, a considerable amount of work is required to explain what this underlying measure of value could be, and it is not entirely clear that this work can be fruitful. By contrast, my account of money is functional: we determine what money *is* by looking at what money *does*. In this regard, Chambers' regress does not have much purchase because synchronically one dollar is, in point of fact, priced as being worth one dollar. Still insofar as the dollar, in some examples, is valued not in a one-to-one correspondence to itself, Chambers' regress is a *prima facie* challenge to fungibility.

I moreover suggested that there are two kinds of defeaters. First there are synchronic defeaters, such as the origami frog, the Walter White hoard and the giving of incorrect change. I argue that these sorts of examples take us too far afield from the money practice. This contention is supported by our discussion of Gresham's law. There is a significant difference between money tokens and currency as such. In the second section I argued that there are problems with Chambers' stratagem regressing to value external to the money practice. One might doubt whether we can point to any selection mechanism which explains why money is able to perform the measurement function it in fact performs. I have argued that Gresham's law provides just such a selection mechanism. The result is that currency units are selected based first on commodification and then on fungibility, until we achieve maximum fungibility as identity. As Warmke pointed out in his Bitcoin example, transitivity becomes an issue. Thus, currency units become measurement units in the same way we abstract other measurement units such as metres and seconds. However, in the case of currency, the accuracy of its units' measurements depends on a stable supply of that currency in circulation.

In the third section, I established that If the **FRIP** is correct, Callender and Chambers are wrong. We do value money. The rate in which it is valued is 'one unit per one unit'. Critical to my argument is how strong *money hypostasis* is and how 'universal' is the 'money universal'. Those with deflationist sympathies will be less convinced by an example that lacks universality. One might object that the measurement function of money is but one among many. The traditional view is that money has three functions: as a medium of exchange, as a unit of account, and as a store of value. If this is the case, then there can be many money types; all I am describing is one particular type. This might pose a challenge to my view that money is essentially a measurement, and measurement takes place through exchange. As I claim here and as Mäki agrees, there is a money universal, it is made up of currencies, and these currencies have monetary tokens. I argued that a considerable amount of misunderstanding is generated when we are not clear about whether we are discussing monetary tokens, currencies or the money universal itself. The selection mechanism of Gresham's law, on my view, has brought about a universal money practice. This universal necessarily involves dynamic time, because (first) at certain times evaluations are absolutely present and (second) there is continual change as to which ones are in fact present.

We saw Chambers ask, 'what does it mean that my £5 is exchangeable for £5?' As he recognised, the fact that the volume of transactions that take place where the dollar is worth a dollar may give us some indication. There aren't that many examples of synchronic exchange, but one is the practice of giving change. There are plenty of exchanges in which one dollar is not worth one dollar; this comes about once extended durations form part of the exchange. I claimed that this is a challenge to the idea of a maximally diachronically fungible dollar. This is what I called the diachronic defeater.

I agree that diachronic fungibility is not a feature of currency units. In fact, money prices itself at different rates depending on the duration of the transaction. This is why we can say that the origin of the representation at the 'zero starting point' is tautological. But as indicated above, it is neither barren nor dimensionless once we introduce a temporal axis. Every point of analysis, every 'zero-starting point', carries with it a set of the things for which it can be exchanged. The 'zero-starting point' has as its origin the dollar being worth a dollar.

A very important take-away from this section is that economics is not the place to look to for answers about money's essence. While money is a specific object of study for economists, not all ontological details are particularly relevant to the issues that interest economists. I think the same can be said about time in the context of physics.

This leads us to the fourth section. Money seems to have synchronic fungibility but not diachronic fungibility. The concept of 'purchasing power' has modal content, which entails that our discounting practice represent a present valuing of future possibilities. This requires representations of temporal axes, but this is not a representation of the future evolution of prices. Rather, it is a synchronic pricing relative to a 'zero-starting point'. This furthered my second goal, as it challenges the idea that seconds are fungible throughout time, even though they are always measured as flowing at a rate of one second per second. In Chapter 6 we will revisit yield curves, and I will argue that these display the dynamism of time more clearly.

Those who employ the TRA to show that time does not flow claim that any self-referential explanation of the flow of time cannot yield a rate. This constitutes the NRA. If the self-referential explanation does not give us a rate then P1 cannot obtain (Miller and Norton 2021, 2). In other words, in no possible world can the flow of time be expressed as a rate. We have also examined a similar argument, the NAP. According to the NAP, if x passes, then the rate at which x passes could be different. However, time cannot pass at a rate other than 'one second per one second'. I claim that these two premises are not contradictory. This is easily demonstrated by the twin's paradox as covered in Chapter 1. In one frame of reference, one twin ages at a rate of one second per one second. In another frame of reference, the other twin ages at a rate of one second per one second. Should their worldlines as their paths through spacetime once again come to intersect we might discover that the twins have aged at different rates – or rather, that one twin is older than the other. How should we describe this difference over time if the rates are the same? The answer is that measurement itself is frame dependent.

Chapter 5: The Embedded Perspective View

Reality and value as mutually independent categories through which our conceptions become images of the world. (Simmel 2005, 56)

5.0 Introduction

In the previous chapter, I showed that there can be impredicative rates. Based on this we can reject the TRA. But opponents to time's flow might still wonder: whence time's dynamism? In this chapter we move to a specific attack on dynamism, one which claims that it is merely a feature of human, perspectival experience of time – what Sellars described as the 'manifest image' (Sellars 1962) – and not a feature of an objective, 'scientific image' of time. I shall call the view that claims that dynamism is merely a feature of our manifest image the EPV. The EPV claims that our awareness of time arises from the perspectives we find ourselves. It is this embedded perspective that is responsible for the "whoosh and whiz" of manifest time (Falk 2003). The EPV maintains that the metaphysics of time should add *nothing* beyond what fundamental physics already posits. In this regard the EPV is a 'physics first' deflationist account.

According to Dyke and Maclaurin (2002), our expressions of tensed emotions are merely evolutionary adaptations. Instead of looking for manifest time in scientific time, the EPV seeks to do some Darwinian reverse-engineering in order to explain why creatures such as we experience aspects of manifest time such as flow or passage and a tensed reality of past, present and future. Defenders of the EPV include Maclaurin and Dyke (2002), Callender (2017), Ismael (2018), Caruso et al. (2008) and A. Fernandes (2021). What I intend to do in this chapter is to construct a composite view constituting the common core of views shared by proponents of the EPV. Since what I am presenting is a composite, I must necessarily gloss over many of the nuances of the actual views taken by each individual defender of the EPV. I will, however, give particular focus to two defenders of the EPV, Craig Callender and Jenann Ismael.

In this chapter we will take a look at a reply to the **FRIP** that I anticipate will likely come from defenders of the EPV. In the last chapter, I argued that *fundamental*

measurement is always frame dependent, where the origin represents maximal fungibility of the measurement unit. This is what constitutes the **FRIP**. I anticipate that the defender of the EPV will offer two objections to this principle.

The first objection says that money can function in many different ways, and the view I have articulated represents merely some contingent type of money practice rather than any universal features. If we can draw some conclusions from money, they will not apply to any possible monetary system but only ones with certain features peculiar to specific temporal and geographical regions. This objection challenges *money hypostasis* as I have described it. This concept of money hypostasis is important because as I have argued so far, money presupposes a metaphysically robust distinction between the past and the future, as well as an objective present that must be subject to change. The deflationist can respond that not all money need have this metaphysical commitment.

The second objection says that, even if we establish that there is fundamentally only one money practice, it is still merely the result of human biases. Thus, it does not matter whether we are drawing conclusions from money or from language – in each case, we are only talking about human kinds. The EPV is willing to accept that empirical evidence might very well suggest that humans experience time the way described by the regimented common-sense image of time, what I will call 'manifest time'. I aim to defend two key properties of manifest time. First, time flows. Second, time consists of three distinct parts: past, present and future. Our money practice depends on these two properties of manifest time, and this is the basis for what I describe as *money hypostasis*.

I will argue that neither of these objections succeed. The first objection fails because, as I have argued already, the money universal I have identified seems to be remarkably cross culturally consistent. The reason for this, I will suggest, is that time really does have the features that our money practice assumes it does. The second objection fails because (as I will argue) what the example of money shows is that even in the physical sciences, measurement units themselves involve self-reference.

The EPV seeks to do some reverse-engineering, and thus so will I. I believe that the second objection may be answered by addressing the practice of science itself. I will argue that scientific practice can be often at odds with supposed scientific posits. This is where I agree with the EPV. At issue is how the scientific image, or more precisely the physical image, of time can generate normative epistemic demands. According to the

EPV, an agent can take a manifest time stance in order to achieve epistemic goals without any metaphysical commitment to manifest time. The question that I will raise is: what sorts of normative epistemic demands does scientific time make, and to whom? I will argue that the EPV is necessarily involved in two contradictions, what I will call the Humean and Moorean contradictions. I will address the second objection by both referring back to the money universal and by analysing self-reference of totalities.

5.1 Objection #1: Money is Contingent

Some EPVers will argue that even though we might all agree that money is impredicative in certain circumstances, this sort of self-reference might simply be an artefact of our specific time and culture, and so it has no deep metaphysical implications. EPVers can therefore say that impredicative money is an entirely localised phenomenon, existing in only certain circumstances. It is hence entirely contingent. Given this, we can make very few inferences about measurement in general by observing its structure. And since it says very little about measurement, it says very little about time.

As I covered in the last chapter, there do seem to be selection mechanisms (such as, I argued, Gresham's law) at play to bring about the existence of money. The EPVer might respond by saying that it is entirely plausible that there are other selection mechanisms. If there are other selection mechanisms, then some types of money might be sensitive to one sort of selectors because of their causal histories, and others might not, because of theirs. There could come about a money that is amenable to a B-theoretic deflationist metaphysics. This is why, in Chapter 4, I paid specific attention to whether money has many, equally fundamental functions that can be balanced and attuned to local needs. As we covered in the last chapter, according to Menger, it is unlikely that money has a teleological explanation on the level of whole societies. It didn't come about because of one or many social designs, so money is not better just because it functions as it was 'designed'. By way of analogy, consider biological evolution. In the same environment, giraffes faced selective pressure that resulted in long necks and gazelles faced selective pressure that resulted in speed. Could something similar happen for money? In other words, could multiple types of money emerge in more or less the same circumstances?

I argued in the last chapter that the answer to both questions is 'no'. The reasons for this are found in the ubiquity of credit, which reflects the strong temporal asymmetry inherent to money. 'Even in the ancient world, credit was not just a legal tool to overcome the complications of cash exchange, but a ubiquitous practice that could increase the money supply...the ancient monetary economy was highly dependent on credit' (Reden 2010, 93). The money practice seems to conform to the money universal even in the ancient world.

5.2 Objection #2: Money Depends on Biased Human Perspectives

The second objection is more intractable. Even if money is the sort of human universal that I claim here, EPVers can claim that the money practice should not have much purchase on the scientific image. It is natural to think that, if we indeed experience manifest time, this *prima facie* counts as strong evidence in favour of manifest time. The EPVer disagrees. We also have an egocentric experience of space, they might aver. In the *Protagoras*, for example, Plato ask us to consider whether things of the same size appear larger *to you* when seen near at hand and smaller when seen from a distance (Plato 1997)(356c–e). This perceptual relativity attests to our innate perspectival bias. Spatially, we are able to construct what Susanna Schellenberg describes as an alter-ego vantage point.

> An alter-ego vantage point is a vantage point that one has as a participant, more precisely, as a potential participant since it is not the location that one is occupying in the moment of perception. Another way of articulating the same point is that an alter ego vantage point is an allocentric frame of reference that is engaged. It is the focal point of a potential egocentric frame of reference. (Schellenberg 2007, 614)

We might characterise an allocentric frame as a composite of all potential egocentric frames. The main take-away is that, as Plato proposed, spatial proximity biases can be mitigated through what Socrates calls 'the art of measure'. Can a similar correction be done for time? EPVers argue that manifest time might be practically indispensable but, since in scientific contexts we are concerned not primarily with what helps us navigate the world to achieve our ends but rather with describing or explaining genuine features of reality, this is not good reason to include it in our scientific image. To make this objection, they give an account of why manifest time happens to be indispensable to creatures like us.

In addition, the EPV must give an account for why many features of manifest time should lie in the manifest rather than the scientific image. The EPVer contends that our typical experience of time can be explained in naturalistic terms without thinking features such as passage reflect genuine, mind-independent reality. As Callender points out, '[m]anifest time is deeply entrenched in us, and its core aspects seem almost universal' (Callender 2017, 24). Since this move can be made with respect to time, EPVers might well make it with respect to money: my analysis extracts from money only what we humans have put into it. This chapter will give an account of the important distinctions made in our manifest experience of time which are necessary features of the money practice.

While these are technically two distinct objections, it is worth recognising that they can be nested within each other. The first objection claims that only specific cultures treat money in the ways that I have described. This leaves open the possibility that there may be other cultures or societies whose money practice does not involve this sort of impredicativity. In the last chapter, I argued that different forms of the money practice throughout history have conformed to the money universal to different degrees. Similarly, different money tokens are able to represent currency units to different degrees. It is important to recognise that the same can be said for any of our measuring practices. It is easy to imagine a culture that does not use money at all. It is also easy to imagine a culture that does not use any sort of clocks. But the mere fact that the use of some sort of clock might vary from culture to culture, with some not using such measurement devices at all, does not show that clocks generally do not share certain essential or unifying features. In particular, whether a clock measures more or less accurately, they measure, or are intended to measure, the same thing. Something analogous holds for value practices. One culture can value one thing very highly and another very lowly. This is true of commodities or goods, and even of individual wants and desires. But these culturally variable evaluative attitudes can always be integrated into an overall system of prices. The money universal, as a system for measuring exchangeable value, easily

accommodates these differences, as evidenced by the fact that price systems often span many currency units. Examples of this can be found in ancient economies.[67]

I will argue that both objections fail, and do so for the same reasons, reasons closely related to the type of creatures we are. In doing so, I adopt the same 'reverse-engineering' strategy of the EPV. In my view, the money universal is not a contingent cultural artefact, nor is it merely a contingent feature of human society. Rather, it is the result of the basic fact that all information gathering, and utilisation systems interact with the world. I will further argue that the temporal distinctions drawn by our money practice do not come about solely in virtue of the views which individual cultures, societies and even species take of time. An important commitment of the EPV is that, because we are the sort of creatures we are, we can rationally make use of convenient fictions without honouring them and giving their contents any ontological endorsement. At this point we need to explain why EPVers think this way.

5.3 Who Are the EPVers and What Are Their Core Commitments?

The EPV is an attempt to reframe the ontological debate between A-theorists and B-theorists in broadly naturalistic terms. This is not an attempt to settle the debate wholesale, but rather to establish that whatever explanatory demands the debate necessarily involves must be recast in naturalistic terms. On these terms, much metaphysical work can be done without taking stands on any substantive ontological questions (such as whether there is an objective present or whether time flows).[68]

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[67] Fritz Heichelheim compared prices, wages, rents and interest rates across the Mediterranean and the Near East in the Third century BC to the first century AD. He claimed that there was significant market integration between the Western and Eastern Mediterranean as well as the Near East. This was evidence by synchronic or contemporaneous price fluctuations and it was easily comparable across local currencies (Reden 2010, 126).

[68] I consider Craig Callender to be a leading EPVer. He thinks that the traditional analytic metaphysics focuses on existence to a fault. 'Almost by definition', existence plays no role in the debate about the nature of time. Conveniently, this safety zone means that this part of philosophy of time can't be threatened by the results of science. Callender thinks that this leaves the philosophers of time unable to do their original job: explaining temporal phenomena (Callender 2017, 290). According to Earman, '[t]he heart of the empiricist loyalty test is just that the properties that distinguish the world where a generalisation counts as a law from one where it doesn't must be epistemically accessible'(Earman 1986, 85). Since, Callender thinks, traditional analytic metaphysics fails this test, empiricists should steer clear of such ontic commitments all together.

Callender argued that the culprit for our misconceptions about time is the self. The problem is that 'as the self is narrating its own story, much of what it uses is what it itself has wrought' (Callender 2017, 261). This is where the concept of 'manifest time' comes into play. Callender says that he 'echoes' Wilfred Sellars's 'manifest image' with his use of 'manifest time' (Callender 2017, 5).[69] 'Manifest time' is a regimented common-sense picture of the world. Since this picture plays such a significant role, according to the EPV, in the separation between the process of science and its product, it is worth briefly reviewing Sellars' work. (It is the embedded, interactive and perspectival aspect of the practice of science that gives the EPV its name.)

According to Sellars, we employ two distinct 'images' of the world, the 'manifest image' and the 'scientific image'. This distinction is useful for the philosophy of time because it gives us a practical way to distinguish between the practitioner of science and the products of science. 'Image' is meant to be ambiguous here: Sellars intended the word to be a metaphor for how we conceive of the world, but it also carries connotations of imagination. These 'images' are things imagined as well as conceived (Sellars 1962, 5). 'Manifest image' and 'scientific image' are thus also meant to convey a certain cognitive activity. Of particular interest here is the seeming requirement that this distinction is useful for *subjects*. As Callender suggests, the human self is the culprit here, but the problem is actually deeper and more wide-ranging than that. Epistemic needs as such are subjective or self-specific, in that the normative demands of epistemology require cognitive relations to propositions.

Like Sellars' use of the broader concept 'manifest image', manifest time is not about direct experience as such. Rather, it is a pervasive and consequential component of the inferences we make with respect to the distinction between causation and of process (Sellars 1962, 18). Manifest time thus closely reflects our intuitions regarding time, including the intuition that there is a tripartite temporal division between past, present and future. How times fit into this division is constantly updated: times that *were* present are now *past*, and time that are now *future* will later be *present*. It is this updating that gives manifest time the feeling of flow and passage. I argued, in the last chapter, that

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[69] In my view, it is reasonable to infer that much of what Sellers says about the manifest image is congruent with Callender' manifest time. I think constructing a composite of the two is unproblematic because I haven't encountered any obvious contradictions between the two positions.

it is this same updating that gives us the 'zero starting point' in a yield curve, the point when a dollar is worth a dollar. These points are the basis for the ability to have a single coherent image of future interest rates at every moment of analysis. The EPVer may not find this a terribly disturbing observation. They simply maintain that, given that each of us occupies an individual perspective, this is exactly what we should expect to observe.

The main insight here is that these two 'images' can, and in fact often do, make conflicting claims. As we have already encountered, manifest time depends on a temporal perspective, namely the present. We can imagine being at different place and different times, but the notion of being at these places 'here' and 'now' is essentially perspectival. Scientific time, as part of the scientific image, is more conceived than imagined. The scientific image emerges from and therefore posterior to the manifest image. This is why I believe that Sellars' original use of the word 'image' is important. An 'image' seems to require a perspective, yet this connotation is absent from Callender's terminology of 'manifest time'. Nonetheless, since this chapter is about the EPV and not Wilfrid Sellars, I will follow Callender's terminology and simply refer to 'manifest time', 'scientific time' and 'physical time'.

The problem, as I see it, is in the presentation of 'scientific time' as part or constitutive of a rival image.[70] In scientific enquiry, manifest time appears 'inadequate' for a deep analysis of time, but this does nothing to detracts from its usefulness *qua* heuristic. For this reason, manifest time continues to support scientific time. According to Sellars, this supporting function does not imply that the manifest image is fixed and static. On the contrary, the manifest image can be refined both empirically and categorically (Sellars 1962). It does, however, carry with it the baggage of the egocentric or perspectival outlook which enables us to move 'in the world' (W. S. Sellars 1962, 31). The concern that the EPVers have is that by changing scientific time to fit or include aspects of manifest time, we are not *optimising science's theoretical and empirical virtues* (Callender 2017, 21, 96, 140).[71] Importantly for the EPV, 'scientific time' makes

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[70] Callender, as far as I can tell thinks of the two images in similar ways to Sellars. According to Sellars, 'although methodologically a development within the manifest image, the scientific image presents itself as a rival image. From its point of view the manifest image on which it rests is an 'inadequate' but pragmatically useful likeness of a reality which first finds its adequate (in principle) likeness in the scientific image' (Sellars 2007, 388).

[71] Callender makes mention of virtues with respect to the goals of science. What this seems to suggest is that we could take an intentional stance towards science as an institution. Science, as such, should take

normative demands on agents in such a way as to imply cognitive relations to propositions. It is my position that this cognitive relationship between agents and propositions is a source for Moorean contradictions, which arise when an agent excludes certain aspects of manifest time from their concept of time.

The problem that Sellars' division raises is that it is unlikely that we can ever reconcile manifest and scientific time, even in the face of what Sellars calls 'the primacy of the scientific image'(W. S. Sellars 1962, 32). We must live with these two distinct and contradictory images, and attempt to see how they fall together in one 'stereoscopic view'. The EPV is motivated by this need for a 'stereoscopic view', in which our practical epistemic needs can be satisfied by the employment of manifest time without simultaneously polluting scientific time with (what the EPVers consider) the faulty or extravagant metaphysics of manifest time.[72]

The EPVers think that the distinction between manifest and scientific time can help sidestep the dispute between A-theory and B-theory of time. The story here goes something like this. A-theory is typically thought of as a regimentation of the image of the world as it is presented to us in our common-sense intuitions. Pretheoretically, time appears both to pass and to consist of past, present and future. Then, the B-theory came along and upended this picture by making radically different metaphysical claims about time. B-theorists sought naturalistic explanations for why time *appears* to pass without presuming that it *does* pass, and typically take an anti-realist stance towards time's flow.

We thus have a typical division between A-theory's reliance on non-naturalistic intuitions and B-theory's reliance on naturalistic explanations – at least according to the EPV. Callender claims that while the A- versus B-theory dispute focused on language and tense, 'physics made do without a distinguished present, a flow or fundamental differences between the past and future. Not only did it muddle through, but it proved to be spectacularly successful' (Callender 2017, 295). This had the result that physical time

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seriously the normative demands of the facts it discovers in such a way as to have motivations: '[t]he motivation for the theory is the idea that physical laws seek to describe accurately as much of the world as possible in a compact way' (Callender 2017, 140).

[72] The general stance that the metaphysics of manifest time is extravagant is a seemingly parsimonious one. It does not do much explanatory work. Callender thinks that while analytic metaphysics, since McTaggart, squabbled over A- and B-properties, '[p]hysics made do without a distinguished present, a flow or fundamental differences between the past and future. Not only did it muddle through, but it proved to be spectacularly successful' (Callender 2017, 294).

is far more austere for reasons of ontological parsimony then even what the B-theory claims. According to Callender, a theory of time which dispenses with the idea of fundamental directionality, C-time, is probably closer to physical time than even B-time (Callender 2017, 301). The only traditional temporal property this leaves us with is dimensionality. For Callender, we should be prepared to be exactly as temporally austere as the physics is. Maybe we should even be prepared to put dimensionality on the chopping block. There are many examples of this sort of strongly timeless theories such, from Julian Barbour's concept of 'Platonia' to Max Tegmark's abstract mathematical objects (Barbour 2001) (Tegmark 2014).

So what are we supposed to do with manifest time? The EPV concedes the need to localise and frame our temporal experiences in order engage in scientific theorising and discovery. However, even though these practices are indispensable to the practice of science, they do not in fact correspond to anything about reality (Callender 2017, 302; A. S. Fernandes 2017, 687; Price and Corry 2007b, 5; Ismael 2024). Scientific time can make do perfectly well by simply considering process and predictability, whereas manifest time is rich with causation. However, as Ismael claims, perspectival concepts like causality and dynamism are indispensable due to the kinds of creatures we are, they are not appropriately applied to totalities. In this thesis, I have argued that money itself is a totality in the same sense described by Ismael. For instance, any consideration of the money array has within its scope money as currencies.

The main commitment of the EPV is that, while perspectival concepts like causality and dynamism are indispensable for creatures like us, they are not appropriately applied to totalities. For instance, according to Ismael, philosophers have a strong tendency to focus on the products of science rather than the practice (Ismael 2018). According to this view, taking an epistemic stance produces this misleading mental picture (Ismael 2011, 460). Defenders of the EPV claim that we can be open to the world having certain sorts of structure or containing certain kinds of things in an epistemic sense without thereby also being open to them in an ontological sense. The first sort of stance may be called one of epistemic openness, and the second one of ontological openness. The challenge for the EPV is to give an account of how the concepts 'now' and 'flow' arise in manifest time without there being anything in our ontology which those concepts properly represent.

This is essentially a pragmatic move. With respect to the practical role that causality and counterfactual dependence play in our lives, a purely epistemic stance of openness is just as good as an ontological one. Thus, the ontological commitment to causality and counterfactual dependence do not do any needed work. This is also the basis for the EPV response to my money example which I intend to construct. The basic idea is that the agent is a self-locating system within spacetime. Decisions are local updates within a larger tenseless structure. Therefore, the deliberation of the money practice presupposes a "now" without requiring a moving present. This is the basic deflationist move. The money practice, the EPV will claim, is just that – a practice. We can get by with mere epistemic openness. No ontological openness is needed.

The EPV will also claim that we can separate the practice of science from the product of science. According to Ismael, we run into problems when we consider the universe as a totality. We are part of the universe, and any attempt to model it as a totality necessarily involves self-reference. However, scientific practice, just like the spatially allocentric views we discussed above, needs interventions. When we consider all egocentric vantage points (in the sense discussed by Schellenberg above) we do not run into problems of self-reference. The same can't be said about interventions. Without interventions there are no experiments. It is self-reference that, I will argue, the biggest take-away from the example of money. Impredicativity, I will argue, answers the TRA.) It is the problem of self-reference that has tarnished ontological openness and the passage of time ever since the TRA of Dunne, Broad and Smart.

Here the EPV makes contact with the debate over the flow of time. According to this view, embedded agents experience the thermodynamic gradient – that is, a variation in the distribution of thermodynamic properties – and this creates an instability in an embedded agent's ability to know the future or even treat it as a potential object of knowledge. Ismael writes that '[this] instability captures the sense in which the future remains for her perpetually open and the passage of time resolves openness into the fixity of fact' (Ismael 2023, 1). However, as we have already covered, this openness describes the field over which money operates very well. It is a subjunctive field, rich in modality. As Chambers claimed about money earlier, it 'always involves two parties and a relation to the future'. Recall that the money practice reflects what Horwich called the decision asymmetry (Horwich 1987, 13). At its very heart is the different standing and status future

and past have. This seems to have been part of the money practice even in the ancient world. The EPV will claim, however, that we need only be epistemically open to this difference and asymmetry. It is this dichotomy between epistemic usefulness and ontological commitment that, I anticipate, will lead to the first objection towards the inferences I have drawn from the money practice from the EPV. The claim is that when some agent has experiences which appear to bear this relation with other agents and the future, what explains this appearance is not something about the structure of the world but instead their knowledge or beliefs.

5.4 The EPV and Evolution

In order to understand the EPV objection, we first need to get a handle on what EPVers think the human perspective and experiences of time get wrong. Next, we need to determine why, if the manifest image is so wrong, it works so well. The usual way we think about how science progresses is that this progress either results or consists in an increase in our ability to effectuate changes and make interventions in the world. Given this important practical aspect of what it means for science to get 'better', acting inconsistently with and indeed contrary to 'better' science should not result in us being able to make more and better interventions than getting things right.[73] As Callender recognises, manifest time, the proto-theory that we bring to scientific enquiry, remains more or less invariant despite what science has to say about the nature of time. He adds that this invariance is likely the result of high-level cognition, and appear to be an entirely natural response. 'High-level cognition' and 'natural responses' should be explainable by some sort of evolutionary reverse-engineering. In contrast, high-level beliefs about scientific time do not seem to be able to fix the low-level beliefs that are demonstrated in everyday language, behaviour and thought (Callender 2017, 14). What is at stake here is not merely a difference in the truth-values of various propositions, but rather a known and intractable contradiction between two equally stable sets of beliefs that not just contradict but we know they contradict, and we don't seem to have any way out of this problem. There are two overarching questions here. First, in the face of such intractably

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[73] There are other beneficial 'getting it wrong' examples. An athlete might get a competitive advantage through over estimating their own skills and abilities.

contradictory beliefs, what sort of normative epistemic demands can both manifest time and scientific time make? Second, who is subject to these normative demands? With respect to the high-level beliefs about scientific time, should we not ask the same questions about the sort of 'cognitive relations' they bear to propositions about scientific time? My view is that both questions can be answered in precisely the same way. We must give a thorough account of what sort of thing can have this 'cognitive relation' to propositions about scientific time. It is probably on this basis that I foresee those with deflationist sympathies will likely respond. The normative epistemic demands of the posits of physical time should play no role whatsoever.

When scientific thought comes in conflict with pre-scientific thought, most of the time we can hone pre-scientific intuitions to make them fit the evidence. For example, it is true that for most of our practical purposes we can build structures, plan roads, and walk down streets using Euclidean geometry. Similarly, we can send people and cellular satellites into terrestrial orbit using Newtonian mechanics. We might even say, in casual conversation, 'the sun will set over there, in the west', and succeed in conveying our meaning to the person with whom we are speaking. Nonetheless, in each three cases, the tools we are using to navigate the world involve or express false assumptions about the world.

Why then do we continue to use them? Quite simply, utility. The reason why we use Euclidean geometry for practical purposes even though the geometry of space is non-Euclidean is that, first, the mathematics needed to do Euclidean geometry is typically much simpler than that needed to do non-Euclidean geometry, and second, for these purposes there typically is not a material difference in outcomes achieved by using Euclidean or non-Euclidean geometry. Likewise, while we can use the equations of general relativity to launch rockets, in most cases there is very little practical difference between doing that and using the equations of Newtonian gravitation. And while we might well regiment away our talk about the sun 'rising' and 'setting', the work needed to do that is totally unnecessary since it will achieve precisely the same practical result.

But the conflict between scientific time and manifest time is importantly different/ When doing science, there is not a simple way of translating our beliefs and dispositions about, first, what interventions we can make and, second, what causes and effects are at play. According to Ismael, causal ideas are heuristic, but the objective content is

supposed to be stochastic. If we take totalities as closed systems, the fundamental patterns in these totalities turn out to be statistical (Ismael 2024; Woodward 2022). According to Ismael, what causal information adds to information about the correlation between two phenomena is information about strategic routes to bring about ends. What causation adds to correlation are the strategic routes (Ismael 2024, 4:21).

It is easy to figure out what bears 'cognitive relations' to the propositions about manifest time. The self bears these cognitive relations. The self's deliberation presupposes a 'now'. The EPV proposed by Price, Maclaurin and Dyke, Callender, Ismael and Fernandez gives a good account of why time appears to pass: it just so happened that evolution just worked out that way. The selection mechanisms of the natural environment weed out creatures that waste energy and care about trying to make causal interventions on the past when that is effectively impossible for creatures like us. We, or rather our*selves*, are rigged with a temporally asymmetric affective structure. This is in some ways similar to the selection mechanism I have discussed which accounts for the existence of money but there is a crucial difference: the selection mechanism for money has weeded out egocentric spatial viewpoints but not temporal ones.

This illustrates how the EPV attempts to explain our experience of manifest time in naturalistic terms. Many EPVers understand that they can be accused of building a substantive theory on top of 'just so stories' (Callender 2017, 274; Maclaurin and Dyke 2002, 284). It seems highly implausible that we will ever find evidence for the evolution of tensed emotions in the fossil record. But even in the face of these 'just so' accusations, these evolutionary explanations are reasonably plausible. Moreover, as Maclaurin and Dyke point out, 'the evolutionary hypotheses we have put forward are in the end empirical and we cannot hope by argument alone to prove that they explain human temporal chauvinism' (Maclaurin and Dyke 2002, 292). Therefore, the EPVers will think that rather than a blemish on the theory, this state of being hostage to empirical fortune is a positive feature, because evolutionary explanations move us in an empirical and fundamentally naturalistic direction.

The EPV thus gives us a rational account of a particular set of temporal representations that can be described as 'manifest time'. It accepts that these temporal representations have been conducive to survival and propagation, as well as to doing good science. However, being conducive to survival or even doing good science does not

make them *true*. The EPV thus claims that the accuracy of the temporal representations constitutive of manifest time is irrelevant for the purposes that drove its origin (Callender 2017, 28). Those with deflationist sympathies can all ways fall back on this position as a response to my arguments here.

At this point, it is worth returning to the second objection made by EPV against the flow of time. This says, recall, that Manifest time is merely a feature of human, perspectival, experience of time (human temporal chauvinism). It is worth asking whether this chauvinism is limited to humans. In order to understand this objection better, we need to figure out what exactly is wrong with the human, perspectival, experience of time. As Callender writes, '[t]he thermodynamic arrow (or whatever is responsible for it) also aligns the memory arrow. The exact details elude us a bit, but it remains extremely plausible that physical and biological facts dictate that we and IGUS suffer from a memory asymmetry' (Callender 2017, 244). IGUS is an acronym of Information Gathering and Utilisation System. Later in this chapter, we will return to the concept of an IGUS. We should ask just how pervasive this 'temporal chauvinism' is or is this alleged bias far broader. This will ultimately form the basis of my argument.

Recall that in the case of the money practice, I argued that Gresham's law drove the selection mechanism which produced the money universal. According to Callender, what seems to produce the memorial structure of our cognition – that is, the relations our beliefs and affective states bear towards our representations of past events – is the entropic gradient. In an earlier work, he gives a good description of how agents are shaped by this gradient:

> It seems to me that we do not explain the asymmetry of counterfactual dependence merely by the fact that our asymmetric world produces agents who colour the world in asymmetric ways. Thermodynamic behaviour not only shapes asymmetric agents but also provides an objective asymmetry in the world. Perhaps it provides the resources for claiming that there is a sense in which the future objectively depends on the past in a way the past doesn't depend upon the future (Callender 1998, 158).

Causation thus seems to be rooted in thermodynamics. This is the case even if all there is to causation is information about strategic routes to bring about ends. Accordingly, creatures like us do better when our affective structure tracks the entropic gradient in some way. The general agreement among the EPVers is that the ultimate culprit in our cognition is the self:

It is the self—the star player in our story of passage—that brings about future events. As the self is narrating its own story, much of what it uses is what it itself has wrought. (Callender 2017, 261)

The EPV holds that the habit of believing that what we see happening is happening *now* is the result of simply believing that we should act only for the sake of things we might cause to occur. But, in point of actual fact, our own actions can only exhibit causal influence over the *future*. Thus, at any time, our dispositions, as well as our beliefs and justifications (and hence our knowledge), are oriented towards the future. This is the decision asymmetry and why deliberation presupposes a "now". We act for the sake of the future not the past. According to Horwich, '[i]t is rational to act only for the sake of things we might cause to occur, and we are well aware that events, including our own actions, can exhibit causal influence only over the future' (Horwich 1987, 10). Likewise, Hugh Mellor argues that we owe this asymmetry to evolutionary adaptation: '[i]n order to survive in our world we need the default habit of believing that what we see happening is happening now" (Mellor 2001, 57). At this point, it is reasonable to ask a question similar to the one raised about money. If the same environment and the same pressures can lead to fast gazelles and long necked giraffes, could there be other evolutionary adaptations that treat time and the self differently, perhaps in a way more congruent with scientific time? I think that the EPV owe us just such an explanation.[74] There are examples in fiction of whose experience of time is not anything like our experience of time. It is thus plausible to believe that the existence of such creatures is at least possible.

When embedded agents consider strategic routes to bring about their ends, they will think that only probabilities of future events get raised or lowered, and probabilities of past events do not. This is not to say that such agents cannot be mistaken about the past. On the contrary, according to Callender,

I'm completely ignorant about vast periods of history, but I don't think anything I do now can affect any of it. I don't know anything about these periods, nor do I deliberate about them in the same way I deliberate about how to 'change' the future. (Callender 1998, 157)

Consider the odds of Leicester City winning the 2015 Premier League. At the start of that season, the odds were between 2,000 to 1 and 5,000 to 1. As the season, progressed those odds fell. Now that 2015 is in the past, the odds of Leicester City

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[74] We will examine this question more closely later in this chapter.

winning the 2015 Premier league are (almost) certain.[75] This (near) certainty will not change no matter how far into the past this event passes. Likewise, the odds of Manchester United not winning the 2015 Premier League are (almost) certain, and this will not change no matter how far into the past this event passes. These odds cannot change, regardless of how temporally far away we get from each event. won't change no matter how far in the past it becomes. This is reflected in the betting practice.[76] These odds cannot change regardless of how far in the past this gets. This is starkly evident when we consider the money practice. The money practice depends on an ontological difference between past and future.

We will never take our present decisions or actions to raise the probability of past events. If that is the case for all agents similar to us, it should be no surprise that they take causal relations that have that kind of temporally asymmetric structure. For such agents to make good decisions, they need causal relations. However, according to the EPV, causal notions are not applicable to closed systems. When we look at the general laws and consider the entirety of spacetime, there are no causal structures whatsoever.

What distinguishes the EPV from other theories of time is that the EPV specifically targets the use of manifest time concepts in scientific practice. It pervasively employs causal notions, except perhaps in physics.[77] It seems clear that these perspectives can lead us astray, but as Ismael correctly points out, all our experimental interventions are perspectival. This apparent contradiction motivates causal republicanism, which attempts to give an account of why manifest time is so important to creatures like us.

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[75] I say 'almost' certain because there are examples in sports of results changing as new facts come to light. Evidence of Lance Armstrong having engaged in 'doping', for example, led to his being stripped of his Tour De France wins after their systematic reevaluation. Leicester City might likewise be stripped of their wins. For example, it may eventually come to light that all the players were robots and not eligible to play.

[76] There are obvious examples of our knowledge of the past being updated as new information becomes available. Consider the example of a goal scored in football. It is now commonplace to use a video assistant referee (VAR). A goal may stand or be rescinded based on the evidence in the VAR of infractions such as offsides, the ball not crossing the goal line fully, the ball not remaining in play or other various fouls. The point is that while a VAR can't increase of decrease the facts of the past, it can change our beliefs about the past. There is even the possibility of betting on the fixed facts of the past. I might for example make a bet with a philology colleague that one of the burnt scrolls from Herculaneum is a lost copy of Aristotle's comedy. Still, the fixedness of the facts in the scrolls cannot be affected by our betting on them.

[77] According to Ismael, '[t]here was a time when science was thought of almost exclusively in causal terms. The mandate of science was thought to be the investigation of the causal structure of the world. Things changed with the mathematisation of science and the triumph of Newtonian theory' (Ismael 2018, 168); 'The real beauty of the SCM (Structural causal models) is that it gives insight into what grounds modal claims in science. Causal models are generalisations of the structural equations used in engineering, biology, economics, and social science' (Ismael 2018, 174).

Causal republicanism is the position that causation is useful, maybe indispensable, but it does not come from the world, God, or in the physics. Rather, causation is constructed by us (Price and Corry 2007a, 1). This view has a long lineage going back to Bertrand Russel's *On the Notion of Cause* (1910). Russell argued that causal notions carried too many ill-fitting associations and therefore should be eliminated from any exact science (Russell 1918, 142). The problem is that such an eliminativist view has made no inroads into the practice of science even though, as Russell claims, 'the reason why physics has ceased to look for causes is that, in fact, there are no such things... it is a relic of a bygone age, surviving like the monarchy' (Russell 1918, 142).

In response, Nancy Cartwright (1979) has argued that causal knowledge is indispensable in practical reasoning. According to Cartwright, what made Russell's eliminativism untenable was that science has to preserve folk intuitions about the world. Causal reasoning and practical reasoning go hand in hand (Cartwright 1979, 420). As Ismael describes, [c]ausal judgements supply the counterfactuals needed to identify strategic routes to action' (Ismael 2018, 172). The practice of science depends on causal information and our actions, as agents, having the status of 'interventions'. Still, EPVers such as Fernandes claim that fundamental physics makes no clear use of causal notions (A. S. Fernandes 2017, 686).

I have identified three core commitments of the EPV.

1. **EPV P1** :For reasons of ontological parsimony, we should not postulate the existence of fundamental properties of nowness or passage unless we have better metaphysical and empirical reasons to do so (Paul 2010, 337).

2. **EPV P2** :Physics is really the only science we have that explicitly takes time itself as one of its targets of study (Callender 2017, 27). It should be the only proper source for empirical reasons[78].

3. **EPV P3**: Folk concepts that go into doing science are not scientific but pre-scientific. They are not metaphysical nor empirical reasons for postulating nowness nor passage.

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[78] Since physics is the only branch of the sciences that specifically targets time, according to Callender physical time is also scientific time.

We are now in a position to summarise the ways in which the EPV generates what I anticipate as the second objection:

EPV Objection #2, **Manifest time is merely a feature of human, perspectival, experience of time.** First, humans have evolved to have what Callender referred to as low-level beliefs about time, as demonstrated in language, behaviour and thought. These low-level beliefs seem to be the consequences of and natural responses to possessing high-level cognition. Second, there is only one branch of science that specifically focuses on time as an object of study: physics. Third, science has theoretical and empirical virtues, and if endorsed with metaphysical seriousness, manifest time does not optimise those virtues but rather bends them. (Note too that money reflects manifest time, as do all the other special sciences; they are all rich with causality.) Therefore, **Manifest time is merely a feature of human, perspectival, experience of time.**

5.5 My Response to the EPV

My response to objection #2 is to challenge its second commitment, which claims that physics should be the only proper source for 'empirical reasons' – that is, for reasons to believe certain propositions about the structure of time which have some empirical foundation. This is because only physical theories can make any sort of ontological claims about what properties of time exist. Our discussion in previous chapters suggests that the money practice and theories that describe it seem to have their own ontological commitments. If there is 'present value' in a theory of annuity pricing, this seems to commit the theory to there being an objective present. If the money practice treats the past different than the future, this seems to commit that theory to an objective distinction between past and future. However, the EPV claims that physics is the branch of science that explicitly takes time itself as one of its targets of study, and thus the only science whose claims about time provide empirical reasons to endorse a theory of time.

As we noted above, the EPV attempts to shift the debate between A- and B-theorists onto naturalistic grounds. For example, Callender thinks there are good reasons to think that the study of time, and any ontological commitments a correct theory of it carries, fall squarely within the domain of physics. The question that I wish to raise here is whether the physics can supply all the aspects of 'time' that we need in an ontological

rather than merely an epistemic sense. An important question that I am raising is whether metaphysics is a domain crossing tool?

A brief recounting of the origin of naturalistic metaphysics will be helpful here. According to Quine, metaphysical debates are to be adjudicated using the same methods used to settle debates within science – namely, by evaluating competing theories with respect to global theoretical virtues, such as simplicity, explanatory power, and integration with other theories (Sider 2011, 166).[79] Callender adopts the same kind of naturalistic approach towards ontology, which holds that there should be a continuity between natural science and properly-done metaphysics. However, different domains of science are committed to different ontologies, which raises what we might call a 'placement problem'. According to Price, there is no need for a second-order science of ontology. Instead ontology gets settled through 'mundane business of existential quantification carried out by first-order specialists in the course of their working lives' (Price 1992, 406). In this respect, my reply is partially in agreement with Price in its pluralism.

This once again demonstrates the considerable amount of confusion involved in theorising about totalities. Price has a clear answer to the question of what exists: '[a]ll there is is the world studied by science' (Price 2011a, 185). On this picture, we do not seem to be able to avoid certain examples of self-reference, since there a robust sense in which science is in the world and can thus be studied by science.[80] Science as a process cannot be external to what there is. As Ismael correctly points out, science consists not merely in products but practice.

It is worth noting that each of the three core commitments discussed above use the word 'reason'. This is significant because it reinforces Sellars claim about the dualism between causation and process (Sellars 1962, 40). 'Reason' has many meanings, but in the premises above, it seems to be doing a great deal of epistemic and normative work. The objection as formulated a few pages ago makes normative demands concerning sorts of reasons count as 'reasons to postulate'. The EPV accepts that creatures like us have reasons to act according to manifest time, but denies that we have good reasons to

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[79] 'Ontological questions, under this view, are on a par with questions of natural science' (Quine 1951, 45).
[80] Price's subject naturalism is 'the philosophical viewpoint that begins with the realisation that we humans (our thought and talk included) are surely part of the natural world' (Price 2011a, 3–6).

postulate the properties of manifest time. Manifest time involves robust change. The sense of change that I have in mind here is McTchange: a robust, mind-independent change in what is present. (For more details on McTchange, see Section 8.1.9) It is this sense of change that underlies heuristic notions like 'intervention' and 'causal explanation'. Interventions presuppose that propositions are able to change truth-value *simpliciter*.

What one counts as the right sorts of reasons will entail specific sorts of normative demands. These normative demands presuppose an agent, but the EPVers do not want to commit to an ontology which includes agents, since they are not entities that we expect to be accounted for in any physical theory. Since only agents want to assign distinct ontological attributes to the past and the future, and this for practical, heuristic reasons, ontological parsimony implies that there is no good reason to include a robust distinction between past and future in one's metaphysics. Naturalists should have no problem with this, as they claim that the interpretation of scientific theories is part of science itself, and hence does not require a kind of reasoning that is completely independent of the way we have discovered that the world is.

Obviously, when doing the sort of ontology that supports various scientific theories, we might want to get away from our narrow action-guiding interests. Empiricists consider ontological austerity to be a theoretical virtue. Quine's approach to metaphysics is often taken to motivate the idea that the ontology we should accept is the one that turns out to be required by science. But it is important, I believe, to notice that this obscures a distinction between what is required by science as theory and what is required for science as practice. These are substantially different things.

The Quinean is ontologically parsimonious: she is existentially committed to the bare minimum of things required for one's theory to obtain and whose existence follows from direct observation or some sort of rules of theoretical confirmation. The EPVer (such as Callender for example) holds that this commitment should be quite stingy – you can use a concept, just do not marry it. This is the division between practice or epistemology of science and the product or metaphysics of science. In this sense, and this sense only, the EPVer is amenable to causal reasoning.

This conception of science is thus perspectiveless. I aim to challenge this picture. I do not think it is logically coherent to strip science of a metaphysics that has agents as

a locus of such desires and a temporal structure that corresponds to this causal reasoning. But there does seem to be an inconsistency with what it is we are trying to achieve, a sort of performative contradiction. Recall what David Hume had to say about causal reasoning:

> It can never in the least concern us to know, that such objects are causes, and such others effects, if both the causes and effects are indifferent to us. Where the objects themselves do not affect us, their connexion can never give them any influence. (Hume 1888, 414)

I think the EPV can be criticised along these Humean lines. There is not a problem with cause and effect *per se*. Rather, the problem is a link between them(cause and effect) that is intelligible to agents, because the ontology proposed by the EPV does not contain agents. Put more simply, without presupposing an ontology where there are agents, it is doubtful that there can be any posits that can make any normative demands whether that be due to empirical reasons or otherwise.

5.6 EPV P1

Now that we have established the ontological parsimony demanded by EPV P2, it is worth revisiting EPV P1. What or who is supposed to be included in the 'we' occurring there?

I will not be disputing EPV P1. If one considers oneself a dyed-in-the-wool empiricist, one should be able to pass what John Earman calls the 'empiricist loyalty test': 'Any two possible worlds that agree on all occurrent facts also agree on laws' (Earman 1986, 85). A loyalty test strikes me as more like the sort of commitment implied by a marriage rather than a statement about a state of affairs such as a stand-in for cause. You might think that you should not commit to a marriage unless you are ready for what such a commitment will involve.

As Cohen and Callender further argue, this loyalty test means that the properties which distinguish the world must be epistemically accessible:

> The loyalty test will have bite so long as, for whatever properties one uses to distinguish W1 [world 1] from W2 [world 2], we require that there is an epistemological story that gives us warranted epistemic access to the instantiations (non-instantiations) of those properties. (Cohen and Callender 2009, 9)

In the principle articulated by Paul, nowness and passage are features of our experience, but the experience of nowness and passage are not 'ontologically robust,

since there is no sufficiently attractive metaphysical or empirical reason for endorsing the existence of nowness or passage' (Paul 2010, 337).[81] If I am to dispute this, then I need to take issue with the meaning of 'ontologically robust'. Many EPVers will even go so far as to concede that organisms such as us cannot have any other perceptions except A-perceptions. According to Falk, 'I for one cannot have non-A-perceptions. Nor is the A-ness of my perception induced by my having A-beliefs about it or any other reflective attitudes such as feelings about it' (Falk 2003, 221). This is where the EPV gets slippery: if one endorses it, one must do so even if it is impossible to have non-A-perceptions. In other words, even if there can only be A-perceptions, this is not evidence *at all* for there being genuine A-properties.

Again, it is worth considering the analogy to spatial perceptions. No one actually experiences the world allocentrically. Instead, we derive an allocentric picture from a collection of alter-ego vantage points. In this respect, there is a significant distinction between money and science. While no one can experience a spatial allocentric perspective, the same cannot be said of the perspectives we adopt in our money practice. Money performs its function without possessing a definite location. The dollar can be traded simultaneously (or at least simultaneous enough) with parties around the globe. We can even determine the velocity *of money* in purely non-local terms. The institution of money is spatially allocentric but temporally egocentric.

The EPV demand for parsimony claims that if there are to be properties of nowness and passage, they must do some explanatory work. Given the other commitments of the view, there should be some physical theory that requires these properties for its truth, or at least for its adequacy. Some physical theories obviously involve time of some sort, but they generally work perfectly well with extremely stripped-down notions of time. As Callender claims, science, as an enterprise, refines our inferential techniques and common sense to such a degree that time gets deflated past the point of meaningfully

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[81] It is worth pointing out that whether we experience nowness and passage it is not a settled matter. For instance, Akiko M. Frischhut argues that it is in fact far from obvious that we can have experiences as of temporal passage, at least insofar as those experiences are supposed to support our belief that time passes (Frischhut 2015, 144). Likewise, Kristie Miller, Alex Holcombe & Andrew J. Latham argue that the use of passage-friendly language causes us to believe that time passes and to describe our temporal phenomenology as being as of passage (Miller et al. 2020). That said, many EPVers do hold that there is in fact an experience of passage and offer explanations for this experience while claiming that it is in a strong sense illusory. This includes Callender (2017), Ismael (2011) and Deng (2011).

counting as time (Callender 2017, 2). This covert eliminativism is precisely the problem with an overly parsimonious view.

How does this sort of reduction take place elsewhere in the sciences? As we discussed in the previous chapter, in spite of economics having money *as its object of study,* it seems to get on perfectly well without any real definition of money. Similarly, economists will describe how value is exchanged without any commitment whatsoever to the existence of something called 'value' nor to claims about its nature. Economics functions just fine without a need to solve the transitivity of identity problem of the dollar. This is something that is of interest for philosophers of social ontology and sociologists.

Physics proceeds by setting out initial, final, or boundary conditions for its laws as expressed in differential equations. These notions of 'initial' or 'final' are intrinsically temporal. The EPVers claim that this language is all well and good for *doing* physics. The practice of physics often proceeds by assuming an initial state, and we guess what happens next. However, these notions of 'initial' or 'final' are not supposed to be part of the *contents* of physics. If in our physical practice what we are interested in are the laws, we do not really need a realist attitude to time. As Forbes correctly points out, '[w]hen scientists presuppose that physics is devoid of McTchange, one should not expect them to discover it in their theories' (Forbes 2025, 137). The EPVer claims that physical time, the time that best works in physics, should be our ontological standard even if it cannot give us the epistemic openness we need in practice. (The problem, I will suggest, is that there is not a clear notion of physical time that we can claim is totally free of the pre-scientific concepts rejected by the EPVer.)

While, as I said, I am not disputing EPV P1 directly, it is worth keeping in mind that while the notions of 'now' and 'passage' bear the brunt of the EPV assault, other properties associated with time are equally under scrutiny. It is also worth keeping in mind that if I accept EPV P1, I must acknowledge that there is a difference-making found in the properties of nowness and passage. It is in answer to the demands of EPV P1 that I intend my money example to have purchase. In order to do that, I need to find something in the money practice that plausibly yields epistemic access to passage and nowness. I think this is founded in the dynamism of the 'zero starting point'.

5.7 Rejecting EPV P3

EPV P3 is supported by the claim that practical commitment to dynamism from within people's perspectives are simply folk concepts which we employ in doing science. They do not constitute empirical reasons; any purported 'dynamism' is a product of an embedded perspective involved in physical practice that does not require any temporal dynamism in a physical theory. Thus, physics provides no empirical reasons to commit to the passage of time; all we have are our practical commitments. The EPVers presuppose a neat division between the epistemology or practice and the metaphysics or product of science. I think this presupposition is mistaken. To see why, we must answer the question 'who is making this commitment?' My contention is that no matter what or who we are talking about, the EPVer is committed two contradictions that seem intractable: the Humean and Moorean contradictions.

The EPV bears an explanatory burden. Pre-scientific structures, concepts and methodology tend to reinforce the manifest image. Many physicists agree with Russell and reject passage and causation and yet these same scientists display a practical commitment to manifest time in the way they do science: in conducting this practice they act as if the manifest view of time were correct. This leaves us with a *Humean contradiction* (Yandell 1990, 113).[82] This is an unresolvable paradox rather than a strict contradiction. Its starting point is the observation that our epistemic efforts rest on more than just reason and evidence. According to Hume, we also need motivations and propensities. But motivations are the sorts of things that *agents* have. Motivations imply personal identity, and selves, and agents, but this does not cohere well with a world that has no room for 'wills' – and the EPV is committed to just such a world. According to Hume.

> [u]pon a more strict review of the section concerning personal identity, I find myself involv'd in such a labyrinth, that, I must confess, I neither know how to correct my former opinions, nor how to render them consistent. (Hume 1888, 633)

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[82] According to Keith E. Yandell 'The Humean labyrinth is comprised by two incompatible lines of reasoning - the "no real connections" line and the "there are real connections" line. The two lines are associated with two incompatible models the Newtonian and the Propensity, respectively. Propensities makes appeal to, acts of the mind, ordering-connections among perceptions, more than mild causal connection' (Yandell 1990, 113).

On the assumption that the EPV is correct, the physicist cannot resolve this practical contradiction. While doing the work of science or simply picking their children up from school, they act in certain ways. They appear to have propensities, implying they have more than just mild causal connections but rather bundles of wants and desires enduring over time. These bundles constitute a person that can remember past events, act morally and immorally, and be held responsible for those actions. They can publish their work, and be held responsible for both the sort of evidence they pick out as justification and the scientific rigour of their experiments. Yet such a physicist may also believe that, at the fundamental level, there are only static relations. More alarmingly, they might posit a world in which there are no such things as propensities and acts of the mind. There are in a strong sense denying themselves.

The Humean contradiction involves having beliefs or sets of beliefs and know that they conflict without having any way of resolving which one is wrong. This isn't merely about having no ability to adjudicate which is correct. Adjudication is a deliberative process that manifest this contradiction. There are some beliefs that appear contradictory but aren't. I can believe that the sun rises in the east and sets in the west and also believe that the sun neither rises nor sets. The apparent contradiction is resolved by making note of the ambiguity of language. In the first belief, 'rising' and 'setting' are merely a *façon de parler*. But the Humean contradiction is much more serious. It is more like believing, at once, the propositions 'if A then not B' and 'both A and B' and having no way to escape the contradiction. Such an unresolved paradox is perplexing enough on an individual level, but might it at times apply to groups and institutions as well? The answer seems to be 'yes', and to an even greater degree than in the individual case. Putnam et al. argue that "rather than ignoring paradoxes or treating them as problems to be solved or eliminated, organizational members need to live with irrationality by holding incompatibilities together (Putnam et al. 2016, 73; Lindblom 1959).

The EPV also faces a Moorean contradiction. According to G. E. Moore, there are many first-person reports that, while not outright contradictory, just strike us as absurd. An oft-cited example is 'it is raining, but I don't believe it is raining' (Schmid 2014, 41). This is importantly different from the Humean contradiction. It raises questions about how independent our beliefs are from the things that justify those beliefs. For example, what

would it mean to say that I believe x, but I also do not believe x to be true? Obviously, we can have false beliefs, but knowing which of our beliefs are false and yet maintaining these beliefs strains oddity into absurdity.

Perhaps the physicist may be able to live with the Humean contradiction, but it is unclear what we are to make of all the Moorean contradictions that will exist in the special sciences. Consider an economist EPVer who claims that 'the drop in interest rates caused inflation but of course I don't believe in causation'. She might think that she's committed to causes, but there are *really* no causes. It might be argued that this denial of causation does not really involve a Moorean contradiction. Rather, what is happening is a similar shift in meaning to the one involved in asserting, for example, both that the sun rises in the east and sets in the west but also that the sun neither rises nor sets. Therefore, the EPVer might conclude, all these seeming Moorean contradictions are resolved when we realise the relevant locutions do not express explicit existential commitment but serve merely as a *façon de parler*.

But this response does not seem to be available in our situation. The Moorean contradiction is implacable when there is not this sort of shift in meaning. The economist thinks that she's committed to causes but there are *really* no causes. What this means, in practical terms, is that, while playing the game of economics, one is allowed to talk about causes and effects, but when one is speaking globally and external to that game, one is not. The EPVers do not want to deny that we have the intimate belief that we indeed experience the world from the point of view of a shifting now. But they also want to maintain the theoretical belief that there is no such thing as the point of view of the now. At issue in the economist example is whether we can shift the meaning of 'cause' in the same contextual way we shift the meaning of the sun 'rising' and 'setting'.

Return again the ice hockey example. If there is a faceoff in one team's end and the attacking team gets off a fast shot that is saved, then everyone, in the context of the game might believe that two seconds passed. If, therefore, two seconds passed, then time passes. So far so good. But after the shot has taken place and the clock stops, time is no longer passing in the context of the game. The B-theorist might point out an equal Moorean contradiction to which the A-theorist is subject: no time has passed, therefore time does not pass; but time has passed, so time passes. In a game between the A-

theorists and the B-theorists both teams can accuse the other at different times of a seeming Moorean contradiction.

Note that the Moorean contradiction is a practical contradiction: it involves someone taking an attitude towards or making an assertion of both their attitudes and their incorrectness. There is no strict contradiction in someone believing that x caused y and that there are no causes, owing to the kind of meaning shift we saw in the case of the 'rising' and 'setting' sun. Rather someone asserting this (or believing it) of themselves creates the practical contradiction. I am well aware that all of us have false beliefs. It's the assertion that one knows which beliefs are false that is absurd. For the economist, at issue is attitudes she takes in doing her work. In order to conduct economic analysis, she must assert that a drop in interest rates caused inflation, but at once as a good scientist she must not be committed to causes. The explanations are merely stochastic.

The case of the performatively contradictory economist illustrates that there is a crucial distinction between the assertions made by science and scientists and the actions of doing science. The EPV argument is one of 'do as I say not as I do' – or rather 'believe as I say not as I believe'. The reason there can be no reconciliation must be found in our psychology. However, the EPVer also believes that we cannot optimise science's theoretical and empirical virtues while sullying it with our psychology.

This will constitute the main focus of my criticism of the EPV P2 and EPV P3. In this thesis, I have endeavoured to remain true to an empiricist approach. Here I think another of Quine's views is particularly apt. We should think of 'the conceptual scheme of science as a tool, ultimately, for predicting future experience in the light of past experience'. As such, '[t]he unit of empirical significance is the whole of science' (Quine 1951). This might even result in the disunity of science: a multiplicity of isolated, non-interconnected sciences. In my view, we need the properties of 'nowness' and 'passage' to explain the fact that we have experiences as of nowness and passage (and change). Once we expand the evidential field, we find all kinds of evidence of the passage of time, particularly when it comes to our social institutions, such as our money or scientific practice. Therefore, *any* objective description of the world can provide the appropriate empirical reasons.

One important question raised earlier that remains to be answered is whether it is possible to have a different psychology, one that does not need to make use of McTchange. I turn to this in the next section.

5.8 The Concept of an IGUS

There are many examples of mythic or fictional extraterrestrials that experience time very differently to 'creatures like us'. There are the Tralfamadorians of *Slaughterhouse 5*, the Traveller in *Star Trek* and the Norns in *Götterdämmerung*. These characters do not just engage in time travel, but rather the content of their experience of time in any situation varies drastically from ours. The main conclusion drawn here is that, as some physicists and philosophers claim, time is an illusion (Hattiangadi 1978; McTaggart 1908; Barbour 2001; Tegmark 2014; Rovelli 2018).[83] If it is an illusion, then perhaps we can imagine beings that 'experience' time veridically – they are not fooled into believing in time by their experiences, as we are, because there is nothing similar in their experiences which could fool them. But our imaginations can only go so far. In this situation we are, in some sense, like the people who occupy 'Flatland' in the eponymous novella(Abbott 2006). [84]

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[83] There is a long history of temporal anti-realism. The Eleatics (c. 5th century BCE), most notably Parmenides, seem to be the first ones to deny the reality of time. Parmenides is notable for making an idealistic distinction between the 'way of truth' and the 'way of seeming'. The former denies the reality motion, while the second, which we mortals must follow, does not. We therefore cannot help recognising motion, even though motion is incoherent. For this reason, Parmenides himself then went on to describe and treat motion as if it were real (Hattiangadi 1978, 14). This is not too dissimilar to the move that the EPVers make.
Still, the static view, the view that owes its linage to Russell's At-At theory, is plausibly a realist view of time. According to Braddon-Mitchell and Miller (2019), we can make a meaningful distinction between what they call 'weakly' and 'strongly' timeless theories. McTaggart would seem to be an obvious candidate for an adherent to a weakly timeless theory, as would Carlo Rovelli. On the other hand, there are strongly timeless theories such as that proposed by Julian Barbour. Barbour claims that the completed theory of quantum gravity will lack both a one-dimensional substructure of ordered temporal instances and any temporal metric, or distance relations. According to Braddon-Mitchell and Miller, it is unclear whether Max Tegmark's position of reality as consisting of abstract mathematical objects is strongly or weakly timeless.
[84] One example in fiction of moving beyond a persistent illusion is the novella 'Flatland'. Flatland tells the story of the interaction between a creature who experiences only two dimensions (the square) as it encounters 'the sphere', a creature that experiences three dimensions. The sphere tries to convince the square that there is a third dimension by trying to demonstrate aspects of 'Spaceland'. This story intersects with the idea of time is an illusion because it is about the possibility that the structure of one group's experience gets things right – in this case, experiencing 'Spaceland' – and the other group still experiencing a persistent illusion.

Callender suggests that there might be a race of beings he calls Martians who experience a time that is orthogonal to ours:

> If Martian scientists cared about an alternative carving of nature into kinds, then presumably they might devise a different system than we do. Let's suppose the direction of strength in that system is orthogonal to ours, so the two temporal directions don't line up. The Martians think that a direction we consider spatial is temporal. Is one of us wrong? (Callender 2017, 154)

These flights of fancy often go unchallenged. While there might be severe limitations on how 'creatures like us' experience time, this should not present similar limitations on our scientific practice, particularly considering that AI systems need not be bound to the limitations of 'creatures like us'. This should not be a mere speculation. We might be able to settle the question by building just such an AI system. In other words, it seems highly plausible that we should be able to build a system which lacks our experience of time on the assumption that manifest time is just an illusion.

Physicist James Hartle (2005) claims that 'past', 'present' and 'future' are neither properties of four-dimensional spacetime nor features of the general laws. Thus, at the fundamental level, there are only static relations. (EPVers are of course amenable to this picture.) Instead, these properties play a role in at most a specific subsystem of the universe. These subsystems can be usefully called Information Gathering and Utilising Systems (IGUSs). Hartle proposes that even though 'past', 'present' and 'future' do not show up in our fundamental physics, conceptualising our experience of the world in these terms still offers an evolutionary advantage over the other modes of organisation. The main reason for this advantage is that any IGUS operating in our region of spacetime will not remember the future because it receives no information about it: 'If the robot processes information irreversibly then its psychological arrow of time must generally be congruent with the thermodynamic arrow of time' (Hartle 2005, 7). The main distinction raised by Hartle that is of interest to EPVers is that subsystems of the world can operate according to manifest time even though, globally, there is no manifest time. In such a model, manifest time is a useful fiction that serves heuristic purposes of problem-solving and decision-making.

Ismael champions this strategy. According to Ismael, the special sciences put a frame around whatever is being investigated (Ismael 2023). Accordingly, within the frame, we can identify wiggles or switches that can be described as causal but step outside the

frame then there are no wiggles or switches. We can make use of McTchange without believing in McTchange. According to this argument, the Moorean contradiction can be avoided depending on the level of the framing. There are in truth no interventions because the interventions themselves are part of the totality. While a focus on the practical allows for modal claims of embedded agents to have some significance, at the global level modality becomes 'weird', as she puts it (Ismael 2018, 181). Ismael thinks that there are no exogenous variables at the global level, but once an embedded agent frames things then variables can be treated exogenously within the frame. That notwithstanding, all exogenous variables can be made endogenous simply by framing things more globally.

This is precisely what is analogous with money. With money there are no exogenous variables(pages 73). So, what does this mean for the economist? She can distinguish framed cause from global cause but even this strategy doesn't completely purge her Moorean predicament. She still ascribes to herself the belief-forming attitudes that she must deny in virtue of denying that there is such a thing as causality. I think there is the same Moorean contradiction when it comes to working for a certain amount of money. You can claim, as Callender that it isn't of value but at the same time you demonstrate that you really do value it because you are willing to work for it.

We can expect the money example to be useful here. Based on the analysis of previous chapters, we want money to be valued exogenously, or as we saw Callender hint at, we want money to be valued *in and of itself*. However, the money practice seems hopelessly endogenous. There are no exogenous variables. Callender concludes that this makes money a fiction (Callender 2010, 65). This is why impredicativity is an important issue for this thesis. In the money schema there are only endogenous variables, and this is characterised by money's impredicativity. A similar view can be taken concerning time.

Returning to the IGUS example, what we see in the processing schema is a stark division between the regions in which information is received and regions in which information is not received. This does not mean that an IGUS has no knowledge of the future. On the contrary, the utilisation part of the system must have some model of future states in order to achieve whatever goals the IGUS has. What this suggests is that an IGUS needs a cognitive infrastructure capable of supporting a reflexive conception of autobiographical history. This is manifestly a feature of human cognition. If we think of ourselves as an IGUS then this cognition depends on our ability to see ourselves on the

cutting edge between what is fixed and what is coming-to-be (where this coming-to-be is merely the boundary of information being received).

Consider an IGUS at the information boundary that it identifies as the present. What the IGUS has (direct or indirect) cognitive access to is the regularities of the past. The IGUS, with its utilisation module, will make projectable generalisations. Still, without some modelling of its own modelling of the world, there would be no way to judge the success or failure of its own models and projections. This is why, as Ismael claims, some autobiographical memory is also required:

> Without autobiographical memory, psychological life would consist of a series of psychological episodes—one thought or experience and then another—with a temporal horizon no longer than a specious present. A being with autobiographical memory, by contrast, has the capacity to survey its past from the earliest recollected Moment in childhood at any point in the course of its life. (Ismael 2011, 468)

One thought experiment that highlights this point is Ismael's 'no natural oracles' argument. She asks us to imagine ourselves in a purely deterministic world. One should imagine that under such conditions, if we were given all the facts of that world's past, we could produce perfectly precise and accurate predictions of its future. If we grant that all past facts are epistemically accessible (at least in principle), if we were to build a robot programmed to predict future states of affairs based on past states of affairs, there could be in principle 'natural oracles'[85]:

> When all contingent limitations on knowledge of the past are removed, a simple computational device that uses information about the past to calculate predictions ought to function as a natural oracle. (Ismael 2019, 480)

However, as Ismael illustrated, there are looping effects. Since it is part of this deterministic world, the oracle system itself passes through itself. This resembles what we saw Price say earlier, that the only things in the world are those things studied by science. It seems clear that there is a robust sense according to which science both is in the world and is something that science studies.

The oracle problem also seems to say something about such a system's dependency on the temporal structure of manifest time:

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[85] 'We say that a universe U contains a natural oracle if a subsystem, S, embedded in U— a human, a computer, a Laplacean Intelligence—is able to predict all the future events in U, from knowledge of its past' (Ismael 2019, 479). She goes on to argue that such an oracle is not possible.

It doesn't matter what information a would-be oracle has about the past. So long as every calculational route from the initial data to the predicted event passes through the prediction, any calculation aimed at prediction will fail. (Ismael 2019, 490)

Recall Quine's claim, raised earlier, that we should think of 'the conceptual scheme of science as a tool, ultimately, for predicting future experience in the light of past experience'. This would work even if there were many isolated and independent scientific enquiries. This seems to lead to the conclusion that science or sciences as institutions function like an IGUS. This leads to a rather strange state of affairs, as Ismael recognises:

If information-gathering and utilising systems are part of the world that they are gathering information about, their own activities are going to be connected in the domain and will produce interference effects. (Ismael 2019, 491)

In fiction we can gloss over this problem and simply claim that a Tralfamadorian can have that sort of experience without explaining *how* they can have such an experience. I do not think that 'science' in anything like our sense can function any other way. We cannot construct a Tralfamadorian science to serve our needs. Humans seem to have an autobiographical memory that spans from early childhood. The IGUS example does not require a whole-life autobiographical memory. All it does require is some mechanism for checking its own success in relation to the horizons it cares about. If, then, we think of the entire scientific project as an IGUS or a series of IGUSs, then this autobiographical memory needs to span centuries or even millennia.

At this stage, what we must account for is the difference between projection and memory. For any information that an IGUS receives, it can make predictive generalisations. In science we might call these laws of nature. Furthermore, as more information is received, these prior predictive generalisations can be tested. There is a continual process of prediction and retrodiction involved in the process of modelling.

This information can evolve both forward and backward in time. There is currently nothing to suggest that our predictive generalisations, what we might call laws of nature, are anything but time-reversal invariant. Thus, the only real difference between (past) retrodictions and (future) predictions is that (past) retrodictions can sometimes be compared to the actual state of affairs. One type of information autobiographical memory gives us access to is our past predictions. We can ask whether there was an appropriate fit between those predictions and the world, whether we got them right.

The relevant point for our purposes is that in the case of some scientific projections, the laws of nature seem to give us very good knowledge of future states of affairs. The problem is that all our information about the future has its origins in this projective process, but our knowledge of the past is not in fact derived from evolving present information into the past. As Callender describes:

> It's not so much that we know more of the past than future than that the world allows a way of knowing the past different from how we know the future. Conditionalizing on the present macrostate, we can know that Halley's comet will return in 2061. Yet that same procedure will not tell us tomorrow's Dow Jones industrial average. Yesterday's Dow average, by contrast, we obtain by simply picking up a newspaper. (Callender 2017, 274)

If we consider the above from the point of view of any IGUS, there is a fundamental difference between how it knows the future and how it knows the past. In the next section we will examine this difference more fully.

A truly diachronic account includes the past. On the other hand, future expectations may very well utilise one or more temporal axes yet still only represent one temporal foliation for the purposes of any given analysis. As discussed in the previous chapter, yield curves are synchronic. There is but a single temporal foliation. We can talk about how something in the past evolved in such a way as to get us to where we are, and we can call this a diachronic analysis, but this description projected forward does not seem as appropriate. Future projections have an influence on the future – they can change the future, and the facts about future expectations are frame-dependent in such a way that is not true of the past. What is missing about future expectations, I think, is that these possess real alethic modality, and this sort of modality says something about the possibility space when it is present. In the next chapter, we will encounter phenomena such as 'term structures at an instant' that show these projections as being much more synchronic.

A significant issue that needs to be considered are the normative demands that any state of affairs make on an IGUS. So far as we know, every physicist is a human being (even though, as Callender speculates, there might be for all we know 'Martian' scientists).[86] Part of my objection to the EPV is that both the Humean and Moorean

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[86] For all we know, there could be some Tralfamadorian physicists somewhere in the universe. Such a physicist would have to have what Ismael calls a 'Laplacian intelligence'. This is a hypothetical super-

contradictions occur together, not just for individuals, but for the entire institution of science. The main feature of the IGUS the EPVer wants to get across is that there are good reasons to take both a 'propensities stance' and a local causal stance that contradicts the lack of global causation. As Callender claims, a belief's being beneficial to survival does not make it true, and perhaps any and all successful IGUSs must function with these two contradictions. This is how the EPVers think that they can get out of the Moorean contradiction: they act as though they live in a McTchanging world without ever committing to McTchange. There is no contradiction to think that money has no value, just as there is no contradiction to believe that there are no causes. And to that extent, they are right.

Where there *is* a contradiction is in working hard to gather evidence in order to 'cause' the right amount of justification needed to claim that interest rates cause inflation, just as there is a contradiction to do the research in exchange for a paycheque in something that has no value.

Callender also writes:

Assume Williams' imagined intelligence is implemented as our IGUS. Embed this organism in the world described. Stand back and ask how it will represent time. Do we expect something resembling manifest time to emerge in its model of the world? While duly acknowledging that I've only scratched the surface of understanding manifest time, I think that the answer is a resounding Yes. We would expect such a creature to divide the world up into past, present, and future, to update this division, to invest deep significance to the past, present, and future, and to believe that time flows. Given the constraints it faces, these emerge as exceedingly natural reactions. (Callender 2017, 305)

I think Callender is right here. Given the world that we live in, we should expect that IGUSs have no option but to invest deep significance into past, present and future. If we consider the IGUS as a total system, it does not much matter whether it infers or perceives time's flow. The *level* of cognition is not the issue. There will be a significant difference here about how any IGUS treats time as opposed to space. While an IGUS must invest the past, present and future with a deep significance, it is relatively easy to think of an IGUS investing no significance whatsoever to 'here' and 'there'. In our earlier

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intelligence that could predict the future but in no way alter it. They couldn't stop their test pilots from ending the universe.

terminology, it is easy to think of a spatially allocentric IGUS but not a temporally allocentric IGUS. This leads to my next reply.

The EPV faces a serious question: are these normative demands simply limited to individual humans doing science, or do they extend to the persisting social institution? There was an accusation of human temporal chauvinism. Perhaps this should be IGUS temporal chauvinism. Hartle's IGUS example is intended to show how a simple robot could take advantage of the heuristics of manifest time. Callender takes the IGUS example further by adding what he calls an 'evolving self-conception' (Callender 2017, 232). It seems that we can take the IGUS example even further and apply it to human kinds such as institutions. If science is a persisting institution that acts as an IGUS, then it too will need to adhere to the normative demands of working with manifest time. These demands have the result that our needs for epistemic openness require ontological openness.

Recall that I identified three core commitments of the EPV. The first is ontological parsimony, the second is the supremacy of physics, and the third that McTchange can be used without being truly endorsed. We are now, however, faced with a problem. It is not just that manifest time is useful for heuristic purposes, it's that it seems *essential* for any functioning IGUS. This is a good reason to think that manifest time is part of the natural world. Even still, this might not be very convincing for those with deflationary sympathies with respect to time. They can always maintain the supremacy of physics.

5.9 The Supremacy of Physics

Why privilege physical time over the times of other scientific theories? Callender thinks that physics has a privileged view of time because

> [p]hysics is really the only science we have that explicitly takes time itself as one of its targets of study. Not only is it studied, but the physical theory of time is repeatedly subjected to rigorous and severe testing too. (Callender 2017, 27)

This is one of the clearest commitments of the EPV. Since general relativity is one of the most successful and rigorously tested physical theories, it should therefore hold a particularly privileged position in how we conceive time.

Here I expect a comparison to money will be helpful. Economics has money as one of its targets of study. Of course, economics cannot claim anything close to the rigour

of physics. However, I will argue that even though economics targets money, the field says very little about the ontology of money. I will argue that this silence is not just a result of lesser rigour. The transitivity of identity of the dollar simply isn't of interest to economists.

We can see how the EPVers will respond to Forbes' notion of McTchange. It is not in the practice of science that we ought to look for reasons to believe that we live in a McTchanging world, but rather in the results of one distinguished branch of science: physics. But there is no need for McTchange in the content of any physical theory, according to the EPV.

My response is that without McTchange, there can be no such things as normative epistemic demands. Epistemic reasoning is practical reasoning, because of its relation to perception and action. As I established with the IGUS example, we need belief-forming reasoning. It is my contention that for any IGUS to be subject to any sort of normative epistemic demand, it must possess autobiographical memory. As Ismael rightly recognises, if we were considering a system with a temporal horizon no longer than a specious present, there would only be a series of psychological episodes (Ismael 2011, 468). I think this applies very broadly to the institution of science, just as it applies to the money institution. In the next chapter, I will offer a discussion of the concept of 'market expectations'. This concept seems to ascribe an intentional stance to both the money institution and the money practice.

At this point, we must ask whether the EPV can escape this IGUS constraint. I think this is an empirical question. Build a system that implements Callender's example of Martian time, and the debate is over. According to Einstein, we have great difficulty 'calling to mind the world of experience without the spectacles of the old-established conceptual interpretations' that come to us from pre-scientific concepts (Einstein 2007, 472) such as causality. Accordingly, there are foundational notions that Einstein claims are concepts absent content (Einstein 2007, 471). These primitive concepts help us to describe the world. They are useful in scientific thought by being aids to the acquisition of concepts that are 'cognitively valuable', but they themselves are not 'cognitively valuable'.

We might consider another metaphor here. These foundational concepts are like a catalyst. They help to start enquiry and speed it up but are absent in the final result.

They remain as a left over. The foundational concept of space ends up being an 'obstacle for describing in scientific language and as scientific thought the essential nature of the pre-scientific concept of space' (Einstein 2007, 472) . However, if the EPV is going to use these concepts in framing the crucial experiments but *not* employ them in the resulting theories, it owes the rest of us an account of why they turn out to be so effective – and more importantly, why they seem to be *universally* effective.

In the next chapter, I will return to the IGUS example. The EPVer agrees there is a stark division in the processing schema between the regions in which information is received and regions in which information is not received. Callender argued that 'it feels as though time flows, in the sense that the present is constantly updating itself. We have a deep intuition that the future is open until it becomes present and that the past is fixed' (Callender 2010, 59), and I agree. Where we differ is in our evaluation of the degree to which science as a social institution can be separated from the necessary Humean contradiction that posits propensities and motivations of the science itself, particularly if we conceive it as operating like an IGUS. The view that I have been defending so far is that metaphysics may go *beyond* the interest of ordinary science, or even one branch that takes time as its object of study, because it takes place across several domains of science. In the next chapter, I will identify different kinds of synchronic future knowledge, the synchronic-diachronic and the evolution through time of past analysis. What this will show is that there is a distinct metaphysical division between past and future.

This chapter faced the objection to my impredicative reply to the TRA which I think is hardest to pin. The EPV accepts that manifest time cannot be eliminated from our day-to-day lives. Money, insofar as it presupposes manifest time, is simply a reflection of this pervasive fiction.

There were two closely related objections here. The first was that what I have offered is a theory of money that might be applicable to our current culture and time, but this is not a human universal as such. It is important to keep in mind that the EPV isn't so much distinct cultural beliefs and practices, but just the general human 'manifest' experience. Therefore, contingent cultural beliefs are easily dismissed. My reply to this objection was that the money practice is, necessarily, a measurement practice. Different people may display extreme differences in which values they ascribe to which good and services, and yet these may all be brought into exchange relations. This measurement, I

have argued, can take place only because of the abstract universal equivalence of money. The second objection is similar to the first. The second objection says insofar as the money practice involve manifest time, this reflects nothing about reality especially but only about human cognitive biases. We only get manifest time out of the money practice because we put it in there in the first place. My response to this objection is as follows. Human beings may be thought of as IGUSs. All IGUSs have the same relation to time. This is strange, since our biases related to the spatial distinction between 'near' and 'far' can be purged from IGUSs like the money institution, which is spatially allocentric. However, we cannot carry out a similar move to eliminate the temporal bias inherent in the concepts of 'past', 'present' and 'future'. Since this relation to time seems universal among IGUSs, this persistent dependency on McTchange suggests there really is McTchange.

It is now worth circling back to one of Callender's claims: 'It seems to me that we do not explain the asymmetry of counterfactual dependence merely by the fact that our asymmetric world produces agents who colour the world in asymmetric ways' (Callender 1998, 157). What really constitutes a problem is not 'the self', nor is it agents. It is the nature of an IGUS. If my claim about science as an IGUS is correct, then the burden now rests on the EPVer to demonstrate, in even a rudimentary way, an equivalence to Callender's Martian example. One should assume that Callender's Martians are IGUS-type creatures. If so, then it really is an empirical question. Produce just such an IGUS!

Chapter 6: Where Is the Dynamism?

There is no more striking symbol of the completely dynamic character of the world than that of money. (Simmel 2005, 517)

6.0 Introduction

The goal of this chapter is to say what it could mean, or be, for reality to be dynamic. If I am to find dynamism in a static representation, then I must give an account of what is deficient about the representation. That is the task of this chapter.

If we recall, in Chapter 3, I argued that this dynamism will not be found in rates. I also argued that we should take a Barrovian view of time. Time implies motion to be measured: we compare motions with one another by the use of time as an intermediary. This is just like the money practice. As covered in the last chapter, Callender acknowledges that there is a similarity between time and money. Physicists are able to summarise the workings of the universe in terms of physical laws which play out in time. This makes time like money because while money makes life much easier, Callender thinks that it is an invented placeholder for the things we value, not something we value in and of itself.[87] This is very similar to Chambers' argument. My argument is that time, just as money, has a Janus-faced nature, and this nature is the basis of the **IRP**. Callender thinks the comparison time to money discredits time by showing it to be merely a convenient fiction. My strategy goes the opposite way: because money is not just a convenient fiction, neither is time.

In this chapter, I will vindicate Simmel's assertion that the world is dynamic and that money is a symbol of the dynamic character of the flow of time. I will do this by looking at the time value of money as expressed by yield curves. Yield curves reflect the temporal discounting that is essential to the money practice. They manifest two

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[87] As we covered in Chapter 1, Callender claims that '[p]hysicists are able to compactly summarise the workings of the universe in terms of physical laws that play out in time. But this convenient fact should not trick us into thinking that time is a fundamental part of the world's furniture. Money, too, makes life much easier than negotiating a barter transaction every time you want to buy coffee. But it is an invented placeholder for the things we value, not something we value in and of itself. Similarly, time allows us to relate physical systems to one another without trying to figure out exactly how a glacier relates to a baseball. But it, too, is a convenient fiction that no more exists fundamentally in the natural world than money does' (Callender 2010, 65).

important characteristics of this practice. First, they are a synchronic-diachronic analysis. Second, they remind us of the diachronic defeater for the fungibility of currency units over time.

In agreement with Simmel, we have so far established that it is essential to money that it be frequently exchanged. When money stands, still it is no longer money. Relative values are always in flux. The measurements represented by exchanges are ephemeral. What all this reflects is the relativistic character of existence:

> Only because reality is in constant motion is there any sense in asserting its opposite: the ideal system of eternally valid lawfulness. Conversely, it is only because such lawfulness exists that we are able to comprehend and grasp that stream of existence that would otherwise disintegrate into total chaos. The general relativity of the world, at first glance familiar to only one side of this opposition, in reality also engulfs the other side and proves to be its mistress where it only appeared to be a party. (Simmel 2005, 517)

What this means is that money is just a special form of the embodied relativity of economic goods, one that signifies their value. I intend to take this way of thinking about money and apply it to time. Time, perhaps like all measurement practices, is also an embodied relativity of all the motions, changes and dynamism in the world. The point that Simmel makes, and which is very applicable to physics, is that laws are inventions which help us grasp that stream of existence. This is the 'certain, fixt and immutable' bias that we encountered with money.

I will argue that physics is not the only place we can permissibly find empirical reasons for committing to the flow of time. The interests of physics are too narrow to fully account for the nature of time, even though physics takes it as a specific object of study. A common objection to the dynamism of time is that time is the wrong sort of thing, the wrong sort of entity to be itself dynamic (Price 1997; Callender 2017; Smart 1949; Horwich 1987; Grünbaum 2012; Ismael 2011).[88] This objection is not about whether the evidence disproves the passage thesis. Rather, it holds that there is not even a clear idea of where to look for the right sort of evidence. Some hold that the idea of time flowing just does not make sense.[89] Part of my goal here is to help make sense of the flow of time.

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[88] "There is a notion of change such that different kinds of events can (do) occur at different time" (Grünbaum 2012, 327).

[89] Huw Price, when asked to explain the flow of time answered, '[l]iterally I don't know, literally I can't make sense of it' (Robinson Erhardt 2023, 13:20).

As we covered in Chapter 5, the EPV holds that causality and dynamism, as concepts, only serve epistemic needs. Accordingly, all that is required to do science is 'epistemic openness' and not 'ontological openness' (Price and Corry 2007b; Callender 2017, 246; A. Fernandes 2021; Ismael 2023). My response, in the same chapter, was that epistemic openness wasn't enough. Without ontological openness, its necessarily produce the Humean and Moorean contradictions, not just for human individuals but also for any and all IGUS. My argument is one of plausibility. Those with deflationist sympathies may not find this fully convincing simply because of their commitment to only accept the posits of physics. What I established is that there are reasons to look more broadly.

In this chapter, I intend to answer the EPV in the following ways. I will consider an economy as an IGUS where the finance practice gathers and distributes information to serve utilisation goals. We can, in the same way, take an 'intentional stance' towards markets and economies. An economy is a social institution,[90] and so if we can think of an economy as an IGUS, we may plausibly do the same for the social institution of science.

For its opponents, what distinguishes the flow of time from other temporal properties such as direction and dimension is that the concept of time's flow, at least how it is conceived by both the B- and C-theories and the naturalistic approach of EPV, is supposed to be incoherent. This is where yield curves enter the fray. As we saw Simmel say, money is a symbol of the dynamic character of the world. I will introduce yield curves in order to demonstrate dynamism in the temporal dimensions of analysis of the money practice. Yield curves say something interesting about self-reference, the establishment of frames and the dynamism of totalities. Price's objection to Maudlin's 'one second per one second' argument is that if we consider distance instead of time, self-reference gives us no insight on dynamism. For Price, self-reference is particularly odious: '[t]he motion of time, then, must be change of time with respect to … What? If the answer, by analogy with motion, is "time", one might be rightly puzzled as to how time (or anything else, for that matter) can change with respect to itself' (Price 1997, 13). I will argue that currency

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[90] To clarify what I mean by the term *intentional stance*, it is helpful to consider the philosopher Daniel Dennett, who coined the concept (along with several other "stances"). Dennett characterizes the intentional stance as treating belief-talk and talk of psychological processes on a par (Dennett 1981, 107). I am making a similar move when talking about process talk for any IGUS.

units change with respect to themselves. In the case of money, the self-reference of currency units is indicative of dynamism in the money practice, and is thus its source.

We require a reference frame to measure motion. Using currency units as an analogue to seconds, I will achieve the goal of showing that impredicative rates make sense. With money, there is an analogous concept that I refer to as the 'zero-starting point'. The analogy with money will also help us achieve the second goal: showing that rates – properly understood – require explanations that presuppose time's flow. As Simmel claimed, Without flow or flux we cannot make sense of our money practice. The flow-invoking explanation of money cannot be easily matched by a flowless explanation.

I will argue that, in the absence of an exogenous measure for time's passage, there was a 'certain, fixt and immutable' bias, the natural consequence of which is to think of time from a temporal Archimedean perspective. An analogous perspective on money is represented by yield curves. The total abstraction can be thought of as an IGUS. I will argue that science is also just such an IGUS. The yield curve will demonstrate the identity of the dollar.

There is a problem however with yield curves. They look to be continuous, but the trading practice is discreet. I will, moreover, offer a refutation of Price's contention that in the case of a dollar exchange, there is the dollar you give me and the dollar I give you. This is because we can see a significant difference between currencies trading at par. The most significant take-away from my examination of yield curves is that they have limits represented by a present. This is the limit of subjunctives, counterfactuals and modality. We can then see that what the TRA proposed was problematic is in fact not: we can unproblematically introduce further temporal axes for the purposes of analysis. Finally, we will discuss the implications of inflation and a changing price of the dollar.

6.1 The 'Certain, Fixt and Immutable' Bias

A common criticism of physical time is that physics mistakenly spatialises time. As Lee Smolin puts it 'motion is frozen, and a whole history of constant motion and change is presented to us as something static and unchanging' (Smolin 2007, 257). Tools like Cartesian coordinate systems do lead to a tendency to treat time like space but in this section, I will argue that there is a far deeper bias at play. As Simmel claims, 'only because

reality is in constant motion is there any sense in asserting its opposite: the ideal system of eternally valid lawfulness' (Simmel 2005, 518).

There is a deep presumption that time ought to be treated as 'certain, fixt and immutable'. It is against this background that we determine whether causality and dynamism are genuine feature of the world. This presupposition is not tenable in the case of money. Our trading practice requires dynamism. I think this gives us good reason to think that all change is in fact McTchange. Simmel makes this point: 'money transcends its significance as a single economic value in order to represent abstract economic value in general and to entwine both functions in an indissoluble correlation in which neither is the first' (Simmel 2005, 518).

One temporal bias is displayed by measuring out duration as a line. We think that time stays, and we go[91]. This bias is shared by some defenders of time's flow or passage. For example, Newton claimed that the order of the parts of time is immutable (Newton 1687, 79). This absolute time (and space) made it possible for him to posit absolute rest: '[r]eal, absolute rest, is the continuance of the body in the same part of that immovable space' (Newton 1687, 78). More recently, Maudlin writes that '[i]nsofar as belief in the reality of the past and the future constitutes a belief in a "block universe", I believe in a block universe. But I also believe that time passes, and see no contradiction or tension between these views' (Maudlin 2002, 259). Whatever change, causality or dynamism there is only unfolds against an unchanging backdrop, displayable by representations such as Cartesian coordinates. The point that I am making here is that there is a broad tendency to think of the totality of the universe from an Archimedean physics perspective in which there is a fulcrum that is static, whether that is an atemporal perspective or the unchanging laws.

This conceptual bias extends to conceiving of the universe as a static block devoid of McTchange. Much has been written about the unobtainability of an Archimedean perspective, a 'fixed point'. However, we should reconsider an older view and combine this with an impredicative type of Archimedean perspective of Simmel. The approach that

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[91] Huw Price is fond of citing the poem 'The Paradox of Time' by Arthur Dobson, as an illustration of how we mistakenly think of ourselves as fixed points past which time flows. Dobson describes the trick of perspective as follows: '[w]e pass, and think we see / The earth's fixed surface flee: / Alas, Time stays, we go!' (Jaszczolt 2023, 43).

I am championing here, however, comes from Barrow. On this view, time is impredicative insofar as time measures change and change measures time (Barrow 2008). Barrow proposed that 'time denotes not an actual existence, but a certain capacity or possibility for a continuity of existence' (Barrow 2008, 35). Emily Thomas argues that Barrow was in fact a modal relationist. According to Thomas, '"modal relationism" grounds the spatiotemporal structure of reality on possible bodies, that could exist but do not' (Thomas 2018, 86). I am not sure what sort of structure we can attribute to the past in Barrovian terms, but it seems clear that our money practice as demonstrated by yield curves is relational and modal in this sense. The futures markets seem to embrace the rich modality of a future that has a capacity or possibility for a continuity of existence, rather than a static thing that is already actualised. In Section 6.8, I will discuss Storrs McCall's 'pruning' concept as it relates to branching time. In spatial terms, this offers a compelling analogy to the yield curve models that I will introduce in Section 6.3.

As with Pollexfen in Chapter 2, there is an old view that 'Coin must "lye dead"' in order to 'support [money] and make it useful' (Pollexfen 1697, 66). Like Locke, Pollexfen thought that because on this model money is a measure, it should be treated as 'certain, fixt and immutable'. Changes in prices are quantified in comparison to this fixed standard. When it comes to physics, for most purposes the rest frame is the one with the observer at the origin (though of course this is conventional). When it comes to any yield curve, during trading, it is the reference to a fixed temporal position that acts as the unchanging present. By contrast, the yield curve, as the content of the graph, bends and contorts as bond prices change.

I will argue that in the case of money, this presupposition of fixity is not tenable. The trading practice requires dynamism in both the frame and the yields themselves. This satisfies EPV P1: we buy money with money. This buying and selling constitutes the measurement practice of money. I will claim that the same relations exist between time and the changes and motions that we measure with time.

6.2 Totality and the Archimedean view

As we established in the previous chapter, from the point of view of any IGUS there is a fundamentally different way of knowing about the future as compared to the past

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(Callender 2017, 274). One place to look for dynamism can be found in something like this synchronic-diachronic distinction. But as we covered in the previous chapter, future forecasting differs from historical analysis. This distinction highlights the possible eliminability of both the direction of time and the past-future distinction. As I have already argued, there cannot be a diachronic analysis of future 'evolutions' over time because of self-reference. The predictive content of any such a supposed 'diachronic' analysis will itself change the evolution of the system it describes.

According to the opponents of time's flow, change is in time, rather than being description of time. A similar tendency exists in our money practice. If we follow the EPV, then we fix our fundamental measures to a frame of reference, but once these epistemic needs are met, we are perfectly able to say that we inhabit a 'certain, fixt and immutable' world. As Ismael claims, what is revealed at the end of time is, surely, what things were like already at the beginning (Ismael 2019, 487). As established in the previous chapter, any IGUS has fundamentally different ways of knowing about future and past (Callender 2017, 274). My contention here, however, is that while the imperative for any IGUS to make distinctions between 'past', 'present' and 'future' is evidence for EPV P1, it is *also* a good reason to reject EPV P2. On my view, the proper source for reasons to attribute certain properties or features to time is not limited to theoretical physics, but spans every entire scientific endeavour. In rejecting EPV P2, I am proposing that metaphysics is a domain-crossing tool. The metaphysics that is implicit in the manifest image goes beyond the particular interest of any specific domain of science, because the manifest image straddles several domains of science. I accept that there are some with deflationist sympathies that will simply reject this domain crossing move. They can stick to their guns and maintain that the only place to look is to physics.

That aside, very IGUS has the bias of having a point of view, a perspective. Price, like Callender, thinks that there is an antidote to this self-imposed bias. For him, the antidote involves figuring out how time differs from space in physics (Callender 2017, 120). Price thinks that when doing physics, we should imagine the 'atemporal Archimedean standpoint', the fixed point or view from 'nowhen' (Price 1997, 114). If we consider everything from a global or total perspective, then there cannot be global change. This Archimedean view, according to Price, treats the past and the future in an

even-handed way (Price 1997, 114). Ismael describes this as the transcendent point of view:

> The very transcendent point of view that gives you access to the total state detaches you from the one that lets you undermine it. In physics, it makes sense to adopt a transcendent perspective for various reasons. But I think that we've been too casual about the legitimacy of that transcendent perspective in drawing philosophical conclusions from physics. (Ismael 2019, 495)

According to her this view is, at least in theory, obtainable at the end of time. It is in this imagined, global standpoint where yield curves become relevant. There is an accessible Archimedean standpoint in the case of money. It is a view from nowhere, but it cannot be from 'nowhen'. Future forecasting differs from historical analysis, and this is why the synchronic-diachronic distinction is salient. The past and future cannot be treated in an even-handed way because of the financial asymmetry. You can buy things in the future but not in the past. According to Callender, physics is really the only science we have that explicitly takes time itself as one of its targets of study. But there is a far more important object of study. Physics is also the science concerned with 'certain, fixt and immutable' laws. Is this standpoint free from its own bias?

The imagined Archimedean vantage point is supposed to have the tools of a fulcrum and lever. In physics, the laws are the fulcrum on which Archimedes can place his lever. But is there something more basic, more fundamental, than mere laws? Lee Smolin, for instance, posits a deep set of underlying laws:

> The burden of explanation then falls on the question of how the initial conditions were chosen. But we know of no rational explanation for how they were chosen, so we reach a dead end, leaving a critical question about our universe unanswered. There's another and much simpler option. We believe that our laws are approximations to some deeper law. What if that deeper law were time-asymmetric? If the fundamental law is time-asymmetric, then so are most of its solutions. (Smolin 2013, 208)

One solution that Smollin's proposes is that the laws aren't fixed fulcrums lying outside the universe, but rather evolve and change:

> I imagined that universes could reproduce by forming baby universes inside black holes, and I posited that whenever this happens, the laws of physics change slightly. In this theory, the laws played the roles of genes in biology. (Smolin 2013, xxvi)

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The point raised by Smolin's thought experiment is not that we do live in such a world. Rather, it is that the imagination of such an Archimedean point is not without its own set of biases. If laws evolve, then the Archimedean perspective they purportedly give loses its supposed mechanical advantage.

Let's return to Price's argument against dynamism: 'A rate of one second per one second is not a rate at all in physical terms. It is a dimensionless quantity, rather than a rate of any sort' (Price 1997, 13). As we saw in Chapter 1, Price claims that if time's flow is dynamic, it must be expressible as a rate. The standard response is that this rate is just 'one second per second'. As we also saw in Chapter 1, the standard reply to this is the non-impredicative TRA. A self-referential explanation shows no dynamism. In response, in Chapter 2, I constructed the MRA. In Chapter 3, I argued that the **IRP** coupled with the **FRIP** dissolves this regress argument.

There is a *prima facie* problem with an Archimedean view. Stepping outside of time and space presents regress problems similar to the ones that are supposed to be problematic for time's flow. Consider the image below. Here we see the physicist Brian Greene standing outside (of a visual representation) of time and space and explaining that all of space and all of time – past, present and future – is equally out there. However, as Ismael correctly points out, such an Archimedean view is missing two things. First, Greene is not outside spacetime. Second, I, the viewer, am not either (Ismael 2023, 8).

(*NOVA* | *The Fabric of the Cosmos* 2011)

It is specifically at this point that the self-referential aspect of money becomes relevant. In most scientific enquiry there is a provisional separation between subject and object, or between investigator and system being investigated. Our talk about time concerns the totality of a fundamental measure. By looking at money synchronically and diachronically we will see that money has totality problems similar to those time has. This is what I call the 'impredicativity of totalities'. The money practice cannot maintain the provisional separation of subject and object. We measure money with money through exchange. As I have argued so far, this self-reference helps us locate the dynamism of time. Price asks how time (or anything else, for that matter) can change with respect to itself. Here we have, in the money practice, currencies changing with respect to themselves.

According to Joseph Schumpeter, 'any satisfactory theory of money implies a theory of the economic process in its entirety' (Schumpeter 2006, 292). There cannot be an analysis of economic theories without an analysis of the process and practice of money. This is true even if one takes a critical stand against that practice. At this point, we have two distinct appeals to 'totality'. There are likewise two distinct discussions of taking an 'Archimedean' view. As George Simmel claimed in his influential *Philosophy of Money*, value is reciprocally determined through the exchange of objects. As S. P. Altmann describes, Simmel's view shows that money gives us a view of the world in which everything is part of the whole (though this 'Archimedean' view differs from Price's):

> [Simmel] looks down upon the market-place of life, the comings and goings of which seem so intricate, where people seem to be jumbled up, and where you look in vain for the Archimedean point from which the earth cannot be moved out of its poles, it is true that peaceful science will not do but from which it can be overlooked at a glance. The world as the great market-place, taken from a bird's-eye view, from which everything is seen in relation to everything else that is the view that Simmel shows us in his Philosophy of Money. Only an economic phenomenon like money, and this before all others, could in its totality give an image of the world in which everything is part of the whole. (Altmann 1903, 48)

In this peculiar economic phenomenon, reciprocal valuation is baked into the money practice, much as with other measuring gauges. Measurement allows us to model and deduce the functional relationships between many different variables. One of these obvious variables is time. Another is modality. The exchange curves, discount curves and interest rate curves involved in our money practice are functions that can be easily

determined. We see the same reciprocity between currency units and the things that can be purchased with currency units as we saw in the Barrovian analysis of the relationship between motions and time: we exchange different things using money as an intermediary. Just as importantly, there are modal considerations: there are things that we *could* exchange for money. Some of these things have clearly displayed prices.

Time is not neutral with respect to money. This is the functional basis of yield curves. The most obvious example of this lack of neutrality is how the present is represented as the origin of these sorts of graphs. The question of whether the past gets treated in an even-handed way relative to the future is not even considered. There is no display of the past *at all*.

From this display of the present as origin, discount functions can be derived, and this derivation gives rise to a financial asymmetry. In economics, some make the distinction between monetary discounting and pure discounting (Broome, 1999, p. 47). In the last chapter, we saw how EPVers look for a rational account of temporal value discounting in relation to a fixed set of 'value in and of itself' (Callender 2010, 65), as though value in and of itself were 'certain, fixt and immutable'. It is only when something is fixed as valuable 'in and of itself' that we can begin to talk about pure discounting.

Monetary discounting involves the management of the money supply and interest rates in order to promote the increase of aggregate economic goals. The typical features of monetary discounting include neutral-to-moderate price increases, in the form of inflation, and the valuing of future money at a discount to present money, in the form of interest. This process might be the only feasible way to realise the benefits of currency. However, pure discounting is a vague concept with ill-defined benchmarks. One significant conceptual difference between these two forms of discounting is that pure discounting can treat time in an 'even handed way'. It makes claims about how positive and negative experiences are valued based on the temporal position of the person doing the valuing. As a result, conceptually pure discount functions can be applied to past experiences. Monetary discounting cannot be applied to past possibility, for the simple reason that, since past experiences cannot be exchanged, money is not able to provide

a measure.[92] Monetary discounting can be measured by money, but pure discounting gauges are harder to define. There is a sort of temporal asymmetry that I call *financial asymmetry*. This financial asymmetry is evidence for EPV P1 as described in the last chapter.

At this stage it is worth looking at a standard yield curve. This will illustrate the point that money and the monetary discounting practice appear to be incapable of temporal neutrality, even when these are conducted from an Archimedean standpoint.

6.3 Yield Curves and the Affine Term Structure

Figure 2: The Yield Curve.
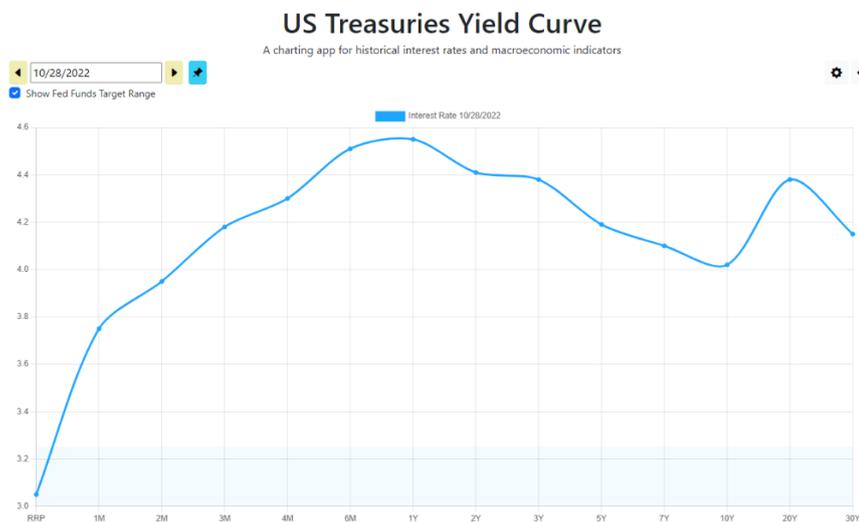
("US Treasury Yield Curve" 2024)

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[92] Many philosophers argue that we can get accurate measures of our past preferences. They introduce scenarios where the possibility of exchange is examined in a hypothetical way. The claim is that any agent will have what Derek Parfit describes as concerns that are purely positional (Parfit 1986, 126). Purely positional properties are claimed to be arbitrary because they do not reflect intrinsic properties of the object of concern. However, insofar as events provide reasons for actions, it is more difficult to distinguish which properties are purely positional. In the case of recent past opportunities, our judgements are difficult to assess because they lack the subjunctive, modal possibility of actually being exchanged. There is some psychological research into the extent of our past future biases. Caruso et al. (2008), for instance, investigated the past/future value asymmetry. The experiments consisted of subjects reading pairs of stories describing two events, one of which occurred a certain amount of time in the future and one of which occurred an equally distant time in the past (Caruso et al. 2008). One strange conclusion drawn from the study is that humans seem to do a lot of *hyperbolic* discounting. When we consider future preferences, we often express preference inversions the further out into the future we go. Yet, in our money practice, we see a rather strange adherence to *exponential* discounting. On the other hand, when it comes to our valuing of the past, we are stymied.

In Figure 2 we see a typical US Treasuries yield curve. [93] As mentioned earlier, there are three things that yield curves demonstrate. The first is what I call the **IRP**. As illustrated by figure 2, the dollar changes with respect to itself. The second is that the IRP is what establishes the reference frame, through what I call the **FRIP**. With a reference frame in place, we can see the dynamism in the entire economic process, because we can coherently answer the question: dynamic compared to what?.[94] The answer is: it is dynamic compared to itself. The dollar is dynamic compared to the entire economic process, conceived as exchangeable for a present dollar (for example, future dollars).[95]

Y-axis values represent the interest rate that is constant until maturity for a given duration. X-axis values represent duration in months or years. Motion and interest are represented in significantly different ways. For brevity's sake, I have not attached a graph representing motion. Let it be sufficient to say that if I did that, the graphs would say different things. As we look along the axis, we see durations increasing from the origin taken to be the present. In the case of the Dollar, this is labelled as RRP. [96]

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[93] I should not be understood as suggesting that there is anything unique about the Dollar. We can expect very similar structures to be present in all currencies that satisfy the money universal. As covered an earlier chapter, it is the tendency for currency units to be maximally fungible that indicates this universal. Money is not reducible or ultimately founded in its tokens. It is abstract, conceptual and performative. Thus, the dollar *simpliciter* is substitutive and non-localised. My theory of money is thus a non-local theory. There are two features of maximal fungibility. The first is that each unit loses all distinctive properties, including a distinct spatial location. (However, as we will see, currency units need to reference a temporal location.) A distinguished present helps to define its identity. What matters is not *where* the dollar is but *when* the dollar is. The second feature is that each currency unit becomes identical with all the others and has value only in relation to the whole system.

[94] Some clarification of IRP is in order. We can think of the point at which a dollar is fully self-referential as the origin of the yield curve. The dollar then has an instantaneous discount rate, but since this point has no duration, the dollar is effectively worth itself – one dollar. I suggest that the same principle may be applied to both temporal and spatial measures. For example, if we consider light cone coordinates, the point in which a proper time second is a coordinate time second is likewise the point of self-reference. Recall Savitt's argument in Chapter 1: '[e]ven an observer who is stationary in some frame of reference still traverses a world-line through spacetime at the same 4-velocity, |u|, and this is now c times the rate of passage of time, dt/dτ. For such an observer, time flows at the rate of one second of coordinate time per second of proper time' (Arthur 2019, 134)

[95] 'We judge identity and agreement by the results of our calculating; that is why we cannot use agreement to explain calculating' (Wittgenstein et al. 2001, 228).

[96] The 'present' in the above graph is not strictly speaking the same as what is labeled as RRP. A reverse repurchase agreement (known as reverse repo or RRP) is a transaction in which the New York Fed, under the authorisation and direction of the Federal Open Market Committee, sells a security to an eligible counterparty with an agreement to repurchase that same security at a specified price at a specific time in the future. For these transactions, eligible securities are U.S. Treasury instruments (Federal Reserve Bank of New York 2013). In practice, this is the overnight rate. This says something important about the present in these sorts of representations: it acts as a limit.

No considerations about interest rates occur prior to the date designated as the present. The y-axis imposes a limit on the representation. In this respect, the question of what dollars are worth prior to the RRP (the present) just does not arise, as there is a limit in the yield curve that corresponds to the present. This is the point in which a Dollar is worth one Dollar. At this point we get self-reference, and it is specifically IRP that defines the frame of reference against which we make measurements.

There is a subjunctive reason for this. There is no way to determine what I could purchase with past dollars. There is, however, a modal artefact displayed in this yield curve – namely, a display of what was possible on that date. The curve itself tells us only what was possible just prior to the close of trading on that date. The measurements that money makes are, as I argued in the previous chapter, ephemeral: once they are in the past, they no longer have any bearing on what is possible in the present. As Simmel claimed, '[t]he individual amount of money is, in fact, by its very nature in constant motion' (Simmel 2005, 517). Money as currency is inextricably linked to circulation. Frequent transactions and frequent circulation are how we make measurements to reassure ourselves of the value of our money.

Consider the following subjunctive conditional: if the present date were 28th October 2022, then I could have purchased a Dollar for delivery on 28th October 2023 for .94 cents. This subjunctive conditional is different from the one which would be true if this was a present yield curve while trading is open. The past modal facts are mere artefacts of the past.

We will see that there are two distinct changes or dynamics. When we see a yield curve that is present, we see that the curve changes and morphs with transactions while the axis remains fixed. As bonds rise and fall in price, the yields on those bonds inversely rise and fall. When the market closes, the axes become dynamic: they shift to the next day's trading. What is striking about the yield curve is the way it displays the closed past in relation to the open future. It is the continuing shifting of the frames of reference for measurements, brought on by IRP, that constitutes the dynamism in the model.

Consider now a yield curve one month earlier:

Figure 3: Yield Curve Succession.
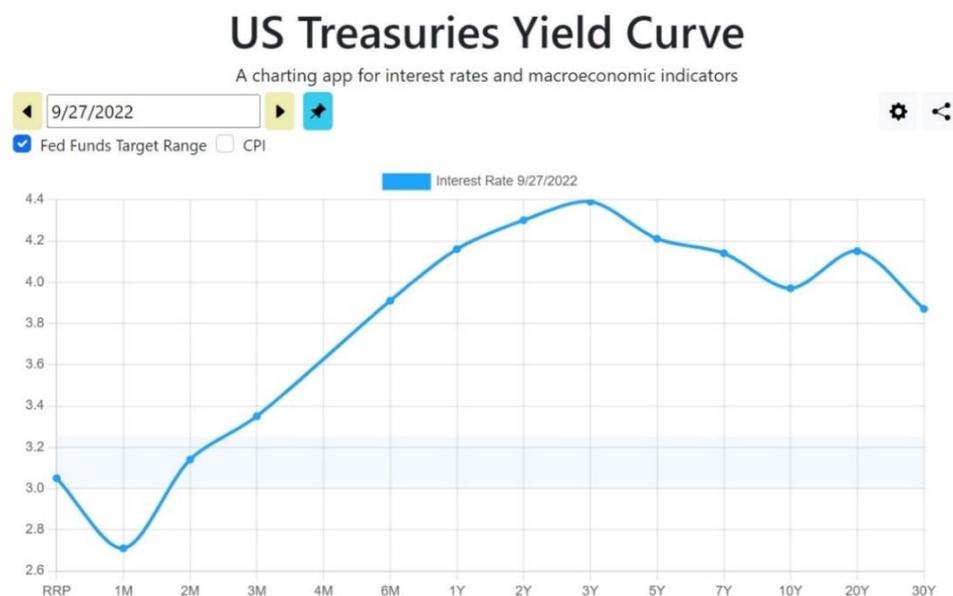
According to Figure 3, the interest rate for the month of October 2022 was supposed to be declining. Yet in Figure 3, all this information seems lost. There is a reason for this. While each yield curve displays a temporal axis, the display is not diachronic. Each yield curve displays a snapshot of the day displayed – namely, of the close of trading on that day. What is displayed is what was possible in the trading environment just prior to closing. As Callender correctly observes about our discounting practice, '[t]he discounting asymmetry should not be understood in terms of a single demand versus time curve, but rather a set of curves, one for each "now" or present"' (Callender 2017, 272). This is precisely what we see for the monetary discounting displayed in each yield curve.[97] It is important to emphasise that each curve is, strictly speaking, synchronic in the sense of synchronic-diachronic discussed in Chapter 4.

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[97] Callender thinks a Humean account of both the temporal value and causal asymmetries is in order: '[w]hy are emotions preferentially activated in response to contemplation of future, as compared to past, events? The answer to this question follows the general outlines of the evolutionary explanation suggested by the developed Humean account. The advantages enjoyed by an organism with a tendency to experience (contextually appropriate) affective states upon imagining future events, relative to an otherwise similar conspecific not disposed to experience such states, should be clear' (Callender 2017, 277). It is worth remembering, particularly with respect to Callender but also other EPVers, that the illusion of the self goes hand in hand with illusions of time flow.

Based on the information about the day trading displayed by Figure 3, if I were present just before closing, I could purchase an overnight deposit maturing the next day (29 October 2022). I could purchase a treasury bill maturing a month from now. I could even purchase a 30-year treasury bond. What I *could not* purchase is an overnight deposit maturing 27 September 2022. This is a result of IRP. 'One dollar is worth one dollar' has the self-reference property only asymptotically in relation to the present. Each single curve has its own unique 'present' or 'now'. While it is fair to say that, for all times, one dollar is worth one dollar, the fact that it has this exchangeability is always indexed to the time that serves as the present.

Most currency units are managed by central banks. A central concern of such banks is the management of stable interest rates in order to achieve macroeconomic goals. Forward interest rates are among the most fundamental tools in finance. David Bolder of The Bank of Canada introduces what he refers to as 'affine models' in his paper *Affine Term-Structure Models: Theory and Implementation*. These models describe the stylised time-series properties of the term structure of interest rates. The goal of these models is to assist with practical debt and risk-management of the central bank. However, Bolder makes a few key observations about the valuing of future dollars and the relation to the evolution of interest rates over time. These observations, I believe, are relevant to the debate over time's flow. According to Bolder,

> [i]t may not appear immediately obvious that we can describe the dynamics of the entire term structure of interest rates from the instantaneous rate of interest. This is accomplished using a no-arbitrage argument. (Bolder 2001, 8)

This is where yield curves have a role to play in our analysis. Strictly speaking, what Bolder describes should be evaluated as synchronic. However, a yield curve has a temporal axis. As Callender correctly points out, even though this sort of graph has a temporal axis, each curve has its own present or now ' (Callender 2017, 272). Since every discount curve has a specific point in time that is now, and they are all unique, we can say that a yield curve is synchronic or has a synchronic relationship to the relevant time slice. What is not immediately obvious is that what serves as the graph's origin is a 'present' or 'now'. I think Callender's IGUS analysis, which we discussed in the last chapter, can be applied to economies, as well as to science as a whole. Furthermore, we can usefully take intentional stances towards these IGUSs. When we think of an economy

as though it were an IGUS, we see in it a 'temporal value asymmetry'. However, it is questionable whether there is a past-future value asymmetry. The question of what value past things have does not arise.

At this point, we need to examine what yield curves say about the value of a dollar at any time. These curves are snapshots, but they also represents an instantaneous forward rate curve, because it sets the rates for buying and selling the dollar with dollars.[98] It also sets the exchange rates for futures trading of other currency units. Since foreign exchange trading takes place 24 hours a day, the yield curves continue to be dynamic even after the close of any particular market. It is the purchasing of dollars with dollars that establishes IRP, and therefore the reference frame. The rates of 'one second per second' and 'one dollar per dollar' were supposed, by many of the philosophers whom we have examined, to be trivial. However, if the purchasing which presupposes this rate didn't establish the reference frame as I claim, one would have risk-free arbitrage profits. I could claim that a year from now, the dollar will be worth a dollar, and I will therefore exchange my dollar a year from now for your dollar now. I could then take that dollar and buy a discounted bond for less than a dollar. A year from now I get more than I paid for it, and I return your dollar and keep the profit. This is exactly what Bolder was referring to as a no-arbitrage argument. The fact that there aren't a lot of people willing to take me up on this offer should tell us something.

As Callender correctly points out, there is in fact a set of such curves, one for each 'now' or present. Each is coherent. However, taken together, these temporal fragments say contradictory things.[99] The dollar is both worth a dollar and, at some point, is discounted and worth less than a dollar. Currency units, like the dollar, rely on FRIP. I will return to this issue in the next section.

The avoidance of arbitrage goes far beyond the structuring of bond market trading. One thing you can get with a 'today' Dollar is, of course, 'future' Dollars. But you can also purchase all kinds of other currencies and derive *their* future or forward rates. Given the

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[98] I have been defending a notion of flow or passage as being as much a change *in* time as a change *of* time. The snapshot model does, however, carry with it some baggage. The assumption is that yield curves take an inherently discrete-time object such as the interest rate and gives it time-continuity.

[99] This picture might be amenable to 'fragmentalism'. Fragmentalism claims that each fragment of reality is internally coherent, but the whole of reality is not. Hence, although the fragmentalist gives up the idea of a reality that is coherent as a whole, she is not compelled to endorse the conclusion that a 'conjunction' of incompatible facts can obtain (Torrengo and Iaquinto 2019, 5).

interwoven nature of these trading practices, it might be more accurate to say that, owing to arbitrage, the market never really closes. This is why, as per Simmel, there is no more striking symbol of the dynamic character of the world than that of money. This is where money differs from motion.

It is because of the conceptual limit represented by an instantaneous interest rate (in which the limit approaches zero duration) that we can say that one dollar is worth one dollar. What this means is that the yield curve does not just tell us about current bond prices. It also tells us about 'market expectations' as something separate from individual expectations. This further suggests that economies are IGUSs. There is a self-constraining feedback loop that forces risk-free arbitrage out of the discounting practice. We will return to the constraints of arbitrage later in Section 6.7.

6.4 The Economic and Scientific IGUSs

So far, in this chapter, I have talked about economies as being IGUS. I now would like to return to the idea that the social institution of science itself is an IGUS. In the last chapter, I discussed the normative demands made by scientific posits. I now want to talk about how these posits make normative epistemic demands on the IGUS of science. It might strike the reader as strange that I am speaking of science, somewhat anthropomorphically, having its own concerns.

What epistemic or ontological commitments does the science institution IGUS carry with it? Since it is a social kind, it is far from clear whether we can separate the ontology from epistemology, as we saw in the last chapter. The money institution, like the science institution, might very well 'accept' posits that no individual accepts. As we discussed in the previous chapter, institutions such as money are not brought into existence by conventional agreement and thus can function on posits which do not involve intentional agreement.

In my view this brings EPV P2 into question. If money can be so opaque to its users, why should we think the scientific view of time – at least, that had by the *practising* scientist – is any different? I will argue that scientific time – the time required for the science IGUS – does not reduce to physical time – the time required to do physics. As I have argued, physics has a particular concern with the laws of nature in such a way as it

is practical and useful to think in terms of immutable laws. Speaking purely metaphorically. The laws are a sort of data compression. They are supposed to describe nature with lossless compression.

How this addressees the Humean approach championed by Callender? According to him, the Humean solution is to look to the causal asymmetry: '[t]he main ingredients are the prevailing causal asymmetry in the world and evolution by natural selection' (Callender 2017, 274). In the previous chapter, we took a look at causal republicanism. Perhaps, in contrast, the science IGUS is hopelessly monarchist. Callender thinks that we should not rush out to find metaphysical explanations. We should stick to psychological and evolutionary explanations for manifest time, rather than commit ourselves to a science which accepts its real existence and thus loses important virtues.

From the point of view of the economy IGUS, the illusion of the self is not the source of its manifest time, though it might be derivative of the illusion of self which every player within an economy in fact has. In spite of that, for the economic IGUS, the temporal horizon matters. Callender, for instance, thinks that the direction of one's temporal horizon of analysis should not matter. Back on page 117 recall Callender claimed:

> To me, the lesson of the foregoing considerations is that metaphysically speaking, as it were, one can get robust counterfactual dependencies in all directions, null, timelike, and spacelike. The world doesn't 'unfold' along the time direction as the tenser hopes, at least not in any way suggested by the physics. (Callender 2017, 179)

What the money example demonstrates is a profound difference in temporal direction. Money demonstrates a commitment to something unfolding along the time direction. All counterfactual dependencies are, at all times, in one direction and in reference to a unique present. There is, however, an important caveat: money is a human kind. If value depends on our dispositions, then the complete elimination of those dispositions, such as would occur with our extinction, would result in a loss of the unit of currency as a unit of measure. Russell surmised something similar with respect to time: a world without experience would be a world without past, present or future (Russell 1915, 212). It might also be a world without any IGUSes. Unlike Russell, I defend the position that past, present and future are real features of our world. This is revealed by our dispositions, but, I claim, also by composites of those dispositions such as social

institutions. Insofar as I am drawing conclusions from our practice, it is worth keeping this caveat in mind.

Manifest time emerges because of perceivers such as us, and Callender thinks it is wise to keep our anthropocentric biases out of our metaphysics. His project is thus to explain why a creature embedded in a physical world such as ours would conceive of the world as we do, in terms of manifest time (Callender and Marshall 2020). I am doing something similar. In contrast, however, I believe that money will clarify misunderstandings about what it means to say that time is dynamic. I think that there is a burden of proof problem. Science seems to be a perceiver-centric project. Even physical theories, such as relativity, require us to think from a perceiver perspective. For example, we postulate light-cone representations in order to explain causality and the relationship with frames of reference.[100]

The money practice depends on our dispositions. Without us, without our experiences there obviously would not be a money practice even if there should remain some money artifacts. Opponents to the flow of time might use this as a possible objection to the money example that I raise here. For now, I will put this aside. In the last section of this chapter, I will revisit this problem and examine potential objections and responses.

My argument here, however, is that science must live with what Sellers calls 'the stereoscopic vision' of both its own scientific image as well as its physical image for the same reasons that the people doing science must live with manifest and scientific time. If this is the case, we should ask, according to the EPV, to whom does physical time make normative epistemic demands? Scientist doing physics? All scientists? Or everyone?

The evidence that I am after will decide these questions can be found by asking how necessary it is for IGUS to accept manifest time. This seems to imply that I am treating IGUSs as agents.[101] This is true, but only in a very attenuated sense. We can treat

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[100] In Minkowski space-time each direction along the light cone is orthogonal to itself (Knox and Wilson 2021). What this means is that all events on the light-cone lie at a null interval from its origin.

[101] Ismael makes a useful distinction between a small-a agent and a large-A agent: '[w]hat we are interested in here is what the lived experience of a creature like this is; what the world would look like from its point of view, over time. Until now, I've been using the notion of agent in a small-a sense, to refer to anything that acts in the small-a sense (i.e., anything whose behaviours are part of what happens). Any material object from a rock rolling down a hill to a snowflake melting in the sun is an agent in this sense, because some of what happens is stuff that it does' (Ismael 2023, 5). The concept of the IGUS serves a very broad middle ground. 'All of the systems along this scale are making use of the record-bearing properties of their

economic IGUSs as an agent in the same sense that we can treat a squirrel as an agent when it stashes away nuts. EPVers are concerned about an anthropocentric bias, but if my view of IGUSs is correct, there is an ineliminable IGUS-centric bias in both economic and scientific life. I therefore advocate a view of science that is, in the words of Simmel, 'a supra-individual organization of contemporary culture' (Simmel 2005, 489).

We can see how this plays out with money in the automation of economic systems. The money practice frequently defies the expectations and beliefs of its practitioners, as Simmel observed:

> This attainment of ends by a transparent and controllable mechanism paves the way for a social ideal that seeks to organize the social totality with the supreme rationalism of the machine and the exclusion of all private impulses. (Simmel 2005, 354)

At this point, we should think it plausible that the money practice is a social institution that came about as the result of an unintentional process. What is astounding is not so much how many share the 'fantasy', but how system still seems to work with so many people believing that it *is* a fantasy. As we saw in our examination of Chambers' argument, the views that 'money has no value' and that 'money has no price' are not uncommon. As Callender says '[money] is an invented placeholder for the things we value, not something we value in and of itself' (Callender 2010, 65).

In spite of this, people who do not value money in and of itself still participate in the money practice. They treat it instrumentally, to be sure, but so does a farmer treat her crops instrumentally when she brings them to the market. Through their actions, these people seem to be engaged a Moorean contradiction of the sort we covered in the last chapter: they think money is worthless and yet they publicly value it.

Thinking of a currency unit such as the dollar as a totality produces problems. For example, it does not coincide with most people's intuitions as displayed with the Walter White example. One serious problem is that we are more prone to think like Price: there is a dollar that you have and there is a dollar that I have, and these are two distinct things. But as we covered in the last chapter, that is not what our money practice is about. The dollar is like a metre: it is part of a metrical structure. The English sentence 'a dollar is

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environment, and it is the thermodynamic gradient that creates the conditions for their existence as agents in these intermediate senses' (Ismael 2023, 6).

worth a dollar' is true by definition, and so in one sense by endorsing it we merely say something analytic, as tautologous as the sentence 'a bachelor is a bachelor'. It isn't even as definitive as 'a bachelor is an unmarried man'. However, just as importantly, we are saying something meaningful and informative about our current practice. It is an analytic truth, but in a restricted sense. What our analysis of yield curves demonstrates is that IRP is what picks out and defines the reference frame we use for making exchanges (as specified in FRIP).

If we think of what you can get for a dollar as a set of objects, every point of evaluation will generate different sets with different contents. Yet at every point of evaluation, the dollar's exchange value, compared to the members of the set, will still be one dollar. These temporal fragments say contradictory things. And yet they play a role in our accounting practice. While Price's intuitive response to Maudlin – that there is 'a dollar I give you and a dollar you give me' – works when considering monetary tokens, its general endorsement is a significant impediment to our accounting practice. Double-entry book-keeping, for example, depends on units of measure that endure and that are fungible, generic and balanced. A debit and a credit do not just weigh the same, they must counterbalance.[102] For every debit there is a corresponding credit, yet they both represent the exact same unit. If I sell something for a dollar, I will debit my cash account and credit my revenue by exactly the same amount.

My argument up to this point is that 'one dollar is worth one dollar' has a certain synchronic meaning relative to a particular time slice. However, it evolves diachronically. At any time, 'the dollar' refers to the totality of our dispositions towards the dollar built up from past experience. Quine's analysis of 'total science' is helpful in this respect: '[t]otal science is like a field of force whose boundary conditions are experience' (Quine 1951, 34). Much like the sensitivity of the entire field of science to experience, the dollar is sensitive to the adjustment of any of our dispositions. This adjustment is made in relation to everything you can get with a dollar considered as a totality, yet one of those things in that set is the dollar itself. In our money practice, exchange is the boundary condition comparable to experience. To paraphrase Quine, having re-evaluated one thing on

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[102] The rules for double entry bookkeeping resemble Newton's third law of motion: 'for every action, there is an equal and opposite reaction' (Newton 1687).

account of a transaction we must re-evaluate some others. The analyticity of 'one dollar is worth one dollar' as an expression depends on the fixed meaning at any particular synchronic time slice relative to a 'now' or 'present'. Is this any different than the rate of 'one second per second'? I see no reason to think it is.

As Callender points out, '[g]ravity distorts time, so that a second's passage here may not mean the same thing as a second's passage there. Only in rare cases is it possible to synchronise clocks and have them stay synchronised, even in principle' (Callender 2010). A caesium clock can provide an extremely accurate measurement of duration, but in carrying out this measurement, that clock will define a frame of reference. Recall that a caesium clock is one of the most accurate measures that we have at present. It can measure proper time with extreme accuracy. Yet there is no way of knowing if any second's passage at every position along that worldline is the same. Much like one dollar being worth one dollar, one second being one second long establishes a frame of reference for that path through that worldline, and this duration will be confirmed by the measurements made by the caesium clock. Analogously to yield curves, there is a point at which we can say that a proper time second is equal to a coordinate time second: the origin of the light cone.

6.5 'Fair Rate of Exchange' Does Not Work

As we covered in Chapter 3, according to Raven, 'the distinction between fair and unfair rates of exchange has no analogue vis-à-vis the rate of time's passage' (Raven 2011, 9). However, as I argued, talk of 'fair' and 'unfair' exchange is a red herring. 'Fairness' is simply a place holder for being more or less money-like. Since, as I have also argued, money as a social institution has come about unintentionally, it is plausible that some people might just acquire importantly wrong ideas and conceptions of it. Sometimes, we may think that we are performing the money practice even when we are not. For example: if my view about the essence of money requiring frequent circulation is correct, then when I put pennies in my piggy bank, I am not participating in the money practice at all.

As I have argued, the abstract, maximally fungible units of money are characteristic of the money practice. There is nothing problematic about selling a very rare bank note for a sum much higher than its face value. Money tokens can gain or lose

symbolic value. However, Raven claims, there is no analogue with respect to the rate of time's flow. On this point, I disagree. If currency units are simply measurement units, then Raven's claim that there is no analogy with time's flow might well be wrong. Just as tokens can instantiate and cease to instantiate their currencies, so can our gauges that we use to measure time measure or cease to measure time. If I over-wind my alarm clock, the cheap spring in the alarm clock causes the clock to run slower than it should. The seconds it beats out no longer correspond in the right way to our time measurement practice. The alarm clock still can be taken (mistakenly) to measure out minutes and hours, but its minutes and hours deviate so significantly from our common understanding of such durations that they are rendered useless. We then say that the clock is no longer accurate. If I were to make the mistake of using that alarm clock one morning, I would probably be late for whatever appointments I have made for the next day. On the view I propose, outdated banknotes are like a broken alarm clock. In order for them to perform their measurement function, I must take them to a bank and swap them for current bank notes.

One objection to the comparison between the second and the dollar is that the rate of exchange between one currency unit and another currency unit is not fixed of necessity. Rather than accepting this as a blemish on my account, I will take this a step further: this fact supports the comparison to time even more strongly. There is a way we can make sense of purchasing currency X for currency X in which the exchange rate is not one unit per one unit. More importantly, this understanding is consistent with our money practice, as we covered when we examined forward rates. This is what happens in the case of borrowing: a loan is a future rate agreement. As such, it is part of the discounting involved in our discussion of Figure 2. A loan is, after all, a short position in whatever is borrowed.[103] What we can expect is that at any moment in time for all currencies, one unit of currency X is worth one unit of currency X. Yet at every moment in time τ there will be a yield curve that can be generated at τ with τ as the origin. 'One dollar is worth one dollar' therefore represents a limit. This accounts for our synchronic and diachronic practices.

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[103] In short selling, a position is opened by borrowing some asset that the investor believes will decrease in value. In the case of a loan, it is the base unit in the currency that is borrowed. The investor then buys some other asset. We can also think of it inversely, as selling the currency that investor thinks will appreciate in comparison to the asset being borrowed (for example a house). The speculation is that the house will rise in value in comparison to the base unit of the currency.

Forward interest rates are among the most fundamental tools in finance. Applications of the discounting of financial instruments, such as zero-coupon bonds and forward curves, include ways of measuring and understanding market expectations.[104] They can, therefore, play a significant role in the implementation of monetary policy. This matters for our purposes because our discount practices are heavily dependent on referencing a present, as shown in our analysis of Figure 2.

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[104] The interest rate at an instant approach is also backed up by Duffie and Kan: '[o]ur yield model is "affine" in the sense that there is, for each maturity t, an affine function. Y,: R" + R such that, at any time t , the yield of any zero-coupon bond of maturity t is Y,(X,)' (Duffie and Kan 1996, 379)

6.6 Discrete versus Continuous

An example of the role that the discount practice plays in the money practice is given by Bolder and Streliski of the Bank of Canada:

> The instantaneous forward rate can be defined as the marginal cost of borrowing (or marginal revenue from lending) for an infinitely short period of time. In practice, it would be equivalent to a forward overnight interest rate. The continuously compounded zero-coupon rate for the same period of time, $z(t,T)$, is the average cost of borrowing over this period. More precisely, the zero-coupon rate at time t with maturity T is equal to the average of the instantaneous forward rates with trade dates between time t and T. (Bolder and Streliski 1999, 5)

This produces a problem even when considering a purely synchronic exchange. We need to take into account duration, as a yield curve demonstrates. But it is only when the duration required to complete a transaction is so small that it no longer meets the materiality test that we can say it is synchronic.[105] Of course this seems to be idealised. We do not expect there to be many purely synchronic transactions. Certainly, in our trading practice, the typical structure is that when the market is open, all transactions are treated as settling at the same time even though the actual transactions take place at different times throughout the day. While trading is open, the clock is fixed insofar as all trading is done in reference to the same RPP with a frozen origin which defines what is 'certain, fixt and immutable'. While trading is open, the yield curve itself moves and changes as trades establish the prices of bonds and forward rate agreements. This market activity reflects discounting and inversely establishes the yields.

The important point that Bolder and Streliski recognise is that the real practice of discounting is not *continuous*. Overnight deposits are significantly different from the infinitely short period described by the function. Yet an affine model demands that the curve contacts the y-axis, for it is at that point we can apply the IRP. What this means is that the economy IGUS reflects the 'evanescence' of the present. For this reason, it makes sense to think of the present as a transactional limit in which the dollar is exchangeable for a dollar. More importantly, this point of self-reference defines the

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[105] According to the Harvard Business School, 'Materiality is an accounting principle which states that all items that are reasonably likely to impact investors' decision-making must be recorded or reported in detail in a business's financial statements using GAAP (Generally Accepted Accounting Principles)'.

reference frame. For our purposes, this seems to correspond with another temporal distinction, between the present and the *specious* present.

In Newtonian terms, the present is an infinitely small part of the continual flux of time. The specious present, on the other hand, is finite and discrete, and corresponds to some small length of time required to perform some specified action such as reading a sentence or responding to a question. It might vary in length depending on the individual involved, but strictly speaking it is a duration, such as half a second up to a couple of seconds, *much* larger than a present which is an infinitely small part of time. Ismael gives a good account of this:

> We are never aware of an instant of time but only of some finite interval, just as we are never aware of a point in space but only of some finite spatial volume. The minimal unit of perceptual awareness has both spatial and temporal breadth. This doesn't mean that we arrive at the concept of an instantaneous state. It means simply that we get that idea by carrying the process of subdivision to its limit, and what we have left when we do so is empty of any experiential content. (Ismael 2011, 464)

As with Bolder and Streliski, perhaps a purely synchronic exchange is not at all obtainable[106]:

> An important and useful concept in the modelling of interest rates is *the instantaneous interest rate*, which we will denote r(t). A heuristic way to consider this concept is as the rate of interest demanded over an extremely short period of time. Practically, therefore, this is analogous to the overnight interest rate. In reality, of course, the instantaneous rate of interest does not exist. (Bolder 2001, 6)

If an instantaneous rate of interest does not exist, then the dollar-per-dollar exchange rate at the limit of the yield curve likewise does not exist. Like infinitesimals, an instantaneous interest rate is a theoretical construct useful for the modelling process but carrying no ontological import, at least none that is very obvious.

The trading practice thus requires its own equivalence to the specious present. Bolder is carrying the process of subdivision to its limit, just as Ismael describes. What I suggest is that the 'one unit of currency X is worth one unit of currency X' schema should be thought of in the same way that Newton thought of limiting ratios: '[t]hey are not sums

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[106] The device of an instantaneous interest rate is in many ways an echo of Newton's use of moments as an infinitely small intervals of time, and is reminiscent of the dispute between Newton and Leibniz over the status of infinitesimals (Arthur 1995).

and ratios of determinate parts, but always the limits of sums and ratios' (Newton 1687, 102). In Chapter 1, I claimed that the definition of a rate was as follows:

R1   All rates are ratios; a ratio is a rate *iff* the numerator and denominator represent distinct things even if they have the same units

As such, the limiting ratio consists of things which are distinctly different up until the limit. In this case, these limits are the abstract maximally fungible units of money, and the idealised point is the one where one dollar is worth one dollar.

Dollars are traded for dollars all the time and in large quantities, but these transactions typically involve some finite duration. It is doubtful that there is any instantaneous interest rate, just as Newton doubted that there were infinitesimals. Yet such a rate is exactly what the affine model demands. In our exchange practice, the smaller the overall value of the exchange (i.e., the less money involved), the less material the length of duration becomes. It is in these rather limited, lower value exchanges that we typically trade one dollar for one dollar, as in the case of giving change. In purely ledger transactions, where the money universal approaches maximal fungibility, there is no transaction equivalent to 'giving change'.

With larger sums of money, duration becomes more material. If I loaned a friend a dollar on the promise of being paid back the next day, interest would not be an issue. Paying back the dollar the next day would suffice. On the other hand, it is common monetary practice in many countries for the overnight rate to set the benchmark interest rate. This is represented in Figure 2, and is labelled as RRP. The central bank sets this rate to target monetary policy. In most circumstances, the overnight rate is the lowest available interest rate, and is therefore only available to the most creditworthy institutions.[107]

The point here is that even in the case of a relatively small duration, a large transaction size can mean that the 'one unit per one unit' exchange rate does not obtain. The model Bolder presents might work perfectly well at the level of national economies, where durations are measured in months and years and transactions are in the billions of dollars. But we should be cautious before concluding it works at the level of infinitely

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[107] According to Bolder, the fundamental building block in fixed-income analysis is a security termed a risk-free pure discount bond. A pure discount bond is a contract that pays one unit of currency at its maturity date. It is termed risk-free because there is no risk of default (Bolder 2001, 6).

small durations and very small amounts of money. I bring this up here to set up a possible objection to my thesis from another approach, Flow Fragmentalism.

My main targets in this thesis are what I refer to as the EPVers, but it is worth keeping in mind that yield curves might support only half of my thesis. Kit Fine's Fragmentalism and 'Frozen Present' argument seem to provide a reason not to try and ground passage in some property of presentness.[108] Flow Fragmentalism is a view inspired by Kit Fine (2005)'s non-standard tense realism. According to this view, reality is divided up into maximally coherent collections of tensed facts. In Chapter 4, I discussed three synchronic defeaters to my proposal, but there is now another possible diachronic defeater: on my view, the dollar seems to have incoherent valuations. One dollar is worth one dollar, but only now.

With this in mind, we can see an apparent incoherence of the yield curve model, one which seems exactly what the fragmentalist has in mind. At every moment, the dollar has multiple possible exchange rates against itself based on the date of the yield curve. These curves can be thought of as coherent, within their 'fragments', but if we consider all fragments jointly, this coherence is lost. According to Torrengo and Iaquinto,

> [t]he claim that there is supervenience between facts in different fragments does not entail that there is a fact binding the different fragments in an incoherent whole; supervenience just requires that, within each fragment, the facts behave in certain ways, vis. they co-vary as described. (Torrengo and Iaquinto 2019, 12)

If we take Torrengo's and Iaquinto's claims seriously, the yield curve demonstrates that reality is not exhausted by the perspective of a single moment. Fragmentalism differs from the EPV, since on this view we cannot simply add up the contents of different times into a unified block (a possibility EPV usually endorses). This is because incompatible facts obtain relative to different moments in time. The point that I would like to stress here is that if you have B-theoretic deflationist sympathies and wish to stick to your guns on the issue of the supremacy of physics then, in the face of the incoherence of dollar valuations then fragmentalism is the best option.

As we covered in the last chapter, the EPV needs to give an account of creatures that are 'not like us' which does away with time. Callender suggests that one criterion to

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[108] An interesting question that lies beyond the scope of this thesis is whether the seemingly tensed facts represented by a yield curve constitute a genuine flow of time, as framed by Giuliano Torrengo and Samuele Iaquinto (Torrengo and Iaquinto 2019, 6).

distinguish time from other dimensions is its narrative potential: '[t]ime is that direction on the manifold of events in which we can tell the strongest or most informative stories' (Callender 2017, 142). Here the fragmentalist project seems to vindicate the flow of time, albeit in a more reduced form than I would prefer. Fragmentalism can maintain that even creatures 'not like ourselves' will still use time to 'tell the strongest or most informative stories'. And since, on this view, a description from a perspective is not dismissed in the same way it is on the EPV, our experience as of time flowing might well ground time's flow.

6.7 Identity: The Dollar I Give You and the Euro You Give Me

Recall our examination of the dispute between Maudlin and Price in Chapter 1. Price thinks that the exchange rate of 'one dollar per dollar' is not analogous to the rate of 'one second per second' proposed for time's flow. He claims that 'Maudlin's exchange rate example misses this point, because it provides two things to tally: the dollars you give me, and the dollars I give you' (Price 2011b, 304).

To be fair to Price, Maudlin makes a similar mistake in discussing the dollar. According to Maudlin, there is a fair rate of exchange based on purchasing power. Therefore, 'a fair exchange of euros for dollars is however many euros will purchase exactly what the given amount of dollars will purchase' (Maudlin 2007, 112). The problem is that currencies are impredicative. As I have already argued, the 'fair exchange' idea is a red herring.

Figure 4: The Euro Yield Curve (European Central Bank 2023)**.**
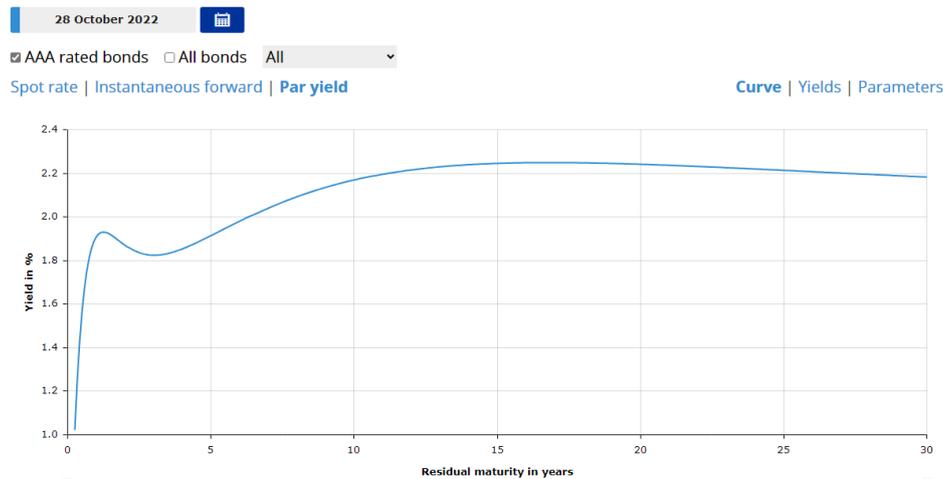
As should be clear by now, I think Price's claim is a significant mistake. We can see how this mistake plays out when we compare the dollar with another unit we may use to tally. In Figure 4, we see a comparable yield curve for the euro on the same day that the euro was trading at par with the dollar. This provides further evidence that the dollar and the euro must be thought of as an abstraction. According to Figure 2, the yield for the US 30-year treasury bonds is almost 4.2%. In contrast, in Figure 4 the yield for the comparable euro 30-year bond is only 2.2%. This means that even though the euro and the dollar are priced at an exchange rate of one dollar for one euro, there is a significant discounting of the dollar in terms of euros when considering delivery 30 years out. If this were not so, I could simply borrow euros to buy dollar treasury bills and make a completely risk-free profit. This is why we have to consider a no-arbitrage argument.

This provides another good reason to think that, in his discourse with Price, Maudlin was right but for the wrong reason. A dollar-per-dollar exchange is not an example of two things being exchanged. It is not like a euro being exchanged for a dollar but rather an exchange of the exact same thing.

Price's reply to Maudlin is as follows:

[C]onsider a graph of the amount of money I give you in currency X, against the amount of money you give me in currency Y. On such a graph, there is a straight line marking the fair rate of exchange: as Maudlin says, exchanges taking place at points on that line can be interpreted in terms of equal purchasing power. And when X and Y are the same currency, the slope of that line is 1. (Price 2011b, 304)

Here we have a real-world example of currency X (the Dollar) and currency Y (the euro) being traded at one-for-one. According to Price, the slope of the line is 1. In Figure 5 we see just such an example.

Figure 5: Fair Rate of Exchange?

This works perfectly well for small transactions. For example, at the time corresponding to Figure 5, I could have gone to my local bank and exchanged my euros for Dollars at a one-for-one exchange rate. It wouldn't matter if I took €1, €10, €100 or even €10,000 to the bank – I would expect to get $1, $10, $100 or even $10,000 back.

So far so good for me and my bank. But at the central bank level, there is a finite number of participants in the foreign exchange trading practice who are asking for a one-for-one exchange rate. Once all the participants asking for an exchange of one-for-one are exhausted, we should expect that the subsequent asks will offer fewer dollars. Instead of asking $1 for €1, they might demand $1.01. In Figure 6, we see a circumstance in which the larger the size of the conversion between euros to dollars, the more expensive the dollar.
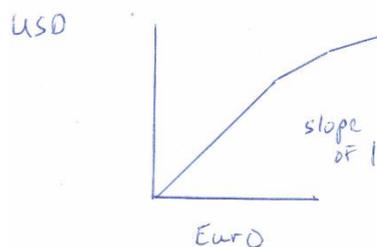

Figure 6: There is No Fair Rate of Exchange.

What if the x- and y-axes represent the same currency? We have already established, in Figure 2, that we can make sense of buying dollars with dollars – but this is done through the purchase and sale of treasury bonds or forward rate agreements.

Imagine the surprise I might cause by calling a foreign exchange trading desk to say that I want to sell my Dollars for Dollars, and that I want that transaction to take place instantaneously or at least at the spot rate. How would such a transaction even settle? Such a pure ledger transaction has no limit. Regardless of the size of the transaction, it would have no impact on the value of the dollar. This is because, in Price's words, it is the 'exact same thing'.

What the yield curve shows us is that our money practice is deeply impredicative. The point at which the dollar has no discount is the point at which it is the 'exact same thing'. On the other hand, even though there is a point in which two *different* currencies might share the same exchange rate of 1 for 1, the stability of this rate depends on market participants continuing to trade at that rate. But even so, at every time there is some potential for this exchange rate to change due simply to more people buying one currency and selling the other. My point is that considering a different currency means considering a different reference frame. We may analogise this to two spaceships which pass each other. They may momentarily share the same (approximate) location, but as they are passing neither shares the other's reference frame, and their world lines only briefly cross. Again, the IRP is what picks out a reference frame.

6.8 Subjunctives, Counterfactuals and Modality

EPVers are committed to epistemic openness without ontological openness. This raises a puzzle: if both directions of time are equally immutable then modality must be grounded in something other than the openness of the future. One solution to this is possible worlds talk. However, we ended up in the same predicament when we considered all possible worlds. What the EPVers thus want is a pragmatic approach to modal content (Ismael 2018, 6).

For our purposes, it is worth comparing our money and language practices, because language can be analysed as it evolves over time. We get the concept of 'synchronic' and 'diachronic' from linguistics.[109] Modality is not of much interest to

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[109] The synchronic and diachronic distinction was first introduced by Ferdinand de Saussure (Saussure 2011). A synchronic analysis of language deals with the state of a language and the linguistic community at a particular point in time. It is studied as a fixed phenomenon existing at a given moment. There is the implicit assumption that it is possible to study language usage without reflecting on their changes over

lexicographers when they do diachronic analysis of language, except insofar as sentences containing modal words are expressions of probability. Their concern is with the present, looking towards the past.[110] The philologist analyses languages historically. As with historians in general, there is a general disdain for modality in philological analysis. Speculation about 'what-ifs' is often referred to as 'counterfactual history', what E. H. Carr calls 'a parlour game with might-have-beens' (Carr 2008, 97). As Martin Bunzl makes clear (Bunzl 2004, 845), the problem with past counterfactuals and the discipline of history is that evidence is central to foundational historical methodology, and by definition you cannot have (direct) evidence for claims that are contrary to the actual facts. Counterfactual history is therefore treated as consisting only of 'acts of imagination'.[111]

What this means for our purposes is that modal facts are naturally purged from an analysis of the past simply because the past is 'certain, fixt and immutable'. But we now have a problem. In the present we *do* have good evidence for subjunctive conditionals, in the possibility space of prices in a marketplace. What follows is an attempt to ground certain kinds of counterfactuals in present pricing structures.

According to David Lewis,

[t]he mysterious asymmetry between open future and fixed past is nothing else than the asymmetry of counterfactual dependence. The forking paths into the future— the actual one and all the rest—are the many alternative futures that would have come about under various counterfactual suppositions about the past. The one actual, fixed past is the one past that would remain actual under this same range of suppositions. (Lewis 1987, 38)

Modal semantics of past counterfactual conditionals require us to think of possible worlds that are identical to our own except for some minor differences. It is not hard to see why historians would rather consider past counterfactuals as interesting fictions and thought experiments if engaging in this kind of counterfactual history

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time. When it comes to language we can think of how tense works in a synchronic analysis. In this respect there is still a horizon of temporality

[110] I have to make a careful distinction here. Obviously, lexicographers are interested in modality as expressed by modal verbs such as would, might, or should. There are obviously future counterfactual expressions. They encode both tense and possibility. However, they are synchronically interested in their deployment in the present and they might also be interested in how they evolved over time. I think it is fair to say that diachronic, particularly in linguistics is an historical analysis. Perhaps, future evolution of language in the present should be treated as I treat yield curves. They are synchronic/diachronic.

[111] Bunzi's reply is that there is good and bad counter factual reasoning. The good reasoning is grounded and the bad reasoning has no grounding (Bunzl 2004, 845).

involves commitment to modal realism, which can be described as quite ontologically explosive. As I think John Earman quite rightly recognised, positing a possible world that resembles the actual world in the past but not in the future does not help to establish the 'openness' that subjunctive modal facts would imply in the actual world by if those same worlds cannot be identical with the actual world for past events (Earman 1989, 203). This suggests further problems for bidirectional ontological closedness.

In finance, directing attention towards the future is far more salient than looking historically into the past. In fact, as with the yield curves, things in the past are often completely ignored. More importantly, there is good evidence on which to ground our attitudes and expectations about how future finance will unfold. What is also interesting is that past modality is not as easy to purge from finance as from history and linguistics. It sticks around as an artifact. Records of the past modal facts exist in the historical records in every generated yield curve. All these 'might-have-beens' form the entire system of prices even though they no longer constitute grounds for action.

We can understand these artefactual modal facts better by means of example. In the summer of 1969, 'advanced' tickets were on sale in most record stores in New York city for the Woodstock Music and Arts Fair (Dowling 2019). Prior to 15 August 1969 one could purchase such tickets, and there are artefacts of both the transactions performed and the sold and unsold tickets. Based on these records, one can get excellent evidence for a few subjunctive conditionals, such as the following: 'if I had been in New York City in early August 1969, I could have purchased a ticket to the 'fair' for the bargain price of $18'. At the point of writing this, I can buy such a ticket for $260, but sadly, the possibility of attending the fair does not come with it. The ticket is valued as an artefact, but just like Roman money artefacts, the ticket no longer functions as a ticket to a music festival. That possibility ended on 17 August 1969. Back then, the dollar was worth something it is not worth now: it was backed by the possibility of exchanging it for the experience of a specific music festival.

Money, as an expression of dispositions, expectations and potential, is always future-oriented. It is future-oriented because it has this conditional structure of 'you could get.' Some of these things you can get are immediately available. An important consequence of money's close dependence on opinion, in my view, is that money's valuation is expressed in the subjunctive mood.

A grammatical mood is an expression of one's attitude towards, among other things, the fulfilment of any particular action. In English, expressions such as 'I could get all sorts of things' is not merely an expression about a present state of affairs, but also about my opinion about the present state of affairs. When I think to myself 'I could get that mango for my pound' in the supermarket, the proposition to which my attitude refers is not strictly speaking in the present. It is not about a real state of affairs at all – rather, the subjunctive indicates an attitude, one of uncertainty, nonfulfillment, unreality, improbability, or impossibility. If we think of this possibility space like a field (as Quine describes) then a transaction or even the lack of a transaction has an effect on the entire field (Quine 1951)[112]. This field comprises the expectations that orient and value the dollar. The limit of this field is the loss of this possibility space; that limit corresponds to the past. In the money practice, the past is ontologically distinct because it lacks the possibility of choices.

This might create a significant problem should we ever figure out how to genuinely travel into the past. Money, just like us, can passively travel into the future by waiting around. If we can actively travel back into the past, then all the things such as a ticket to the Woodstock Music and Arts Fair would once again represent a real possibility of attending. One upshot of the temporal asymmetry that I have argued is baked into the money practice is that is difficult to imagine the practice surviving the invention of time travel. Just as the development of an IGUS that is temporally allocentric would cause me to seriously rethink my position so would the development of time travel.

In the previous chapter we examined how, at least according to Ismael, focus on the practical allows modal claims of embedded agents to have empirical significance, for it is only at the global level that modality becomes 'weird' (Ismael 2018, 181). It is only when we examine the world as sliced up into embedded subsystems that modality is useful. As Storrs McCall recognises (and in this he is in agreement with Ismael) there is no room for the flow of time in the universe as represented by Minkowski spacetime. However, McCall argues that replacing Minkowski spacetime with a branching model restores the possibility that time may flow. McCall's branching model is as follows. In the

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[112] Re-evaluation of some statements entails re-evaluation of others, because of their logical interconnections

past, there is a manifold congruent with Minkowski space time in that there are no branches and events are laid out in such a way as to lend themselves to four-dimensional coordinate mapping (three spatial coordinates and one temporal). Enduring objects occupy a volume of spacetime. McCall claims that the present represents 'first' branching points, and the systematic removal of branches is what constitutes time's flow (McCall 1996b, 29).

What McCall lays out closely approximates what I suggest happens in the money case. The money practice is concerned with what is possible, and it is the ever-steady elimination of possibilities that constitutes both the evolution of yield curves over time and the gradual shift in the origin of those yield curves. The money practice is deliberative: it is based on the idea that some currency can get you all sorts of things. As Storrs correctly observed, '[a]s we have seen, deliberation requires a minimum of two alternative courses of action open to the agent, each one of which he can perform' (McCall 1996a, 255). Deliberation presupposes a 'now'. When a financial deal is made, it become past tense, and all other alternative branches (representing other deals which were possible before the one that was in fact made was actualised) fall away. The further into the past these transactions are, the less reliable the measurements that they represent.

In synchronic terms, it is only the current time slice, the present time slice, the time slice *now* that has a horizon of temporality, simply because there are some modal facts about what can happen in the future. When we examine past time slices synchronically, they are stripped of any horizons of temporality they once had.[113] All horizons of temporality that are raised are dealt with diachronically.

It is reasonable to ask, at this juncture, where I am going with this talk of modality and counterfactuals. Recall that Callender thinks there are robust counterfactual dependencies in all directions. I am arguing that this is false: past modal facts are nothing more than an echo of the ones that exist in the present. The practical significance of modality is how it allows us to talk about how open systems *would* behave if acted on in

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[113] The notion of a 'temporal horizon' can be traced back to Husserl: '[e]ach momentary perception is the nuclear phase of ...a continuity of a momentary gradated retention on the one side, and a horizon of what is coming on the other side: a horizon of "protention," which is disclosed to be characterised as a constantly gradated coming' (Husserl 2012, 154).

various possible ways. It seems difficult for the EPVer to have *any* account of global modal facts, but the view I offer does. Moreover, the example of a global practice of money gives us an idea of where we might find dynamism in our money practice – namely, in the observable elimination of modal facts as yield curves evolve over time.

6.9 Dynamism

One might still be wondering where the dynamism is supposed to come from. The hurdle posed by Price is that I need to produce a self-referential rate for time's flow that both is unlike any dimension of space and shows some measure of dynamism. As discussed earlier, there are two ways in which the yield curve representations are dynamic. The first resembles how we represent typical motions, and is more amenable to *at-at* representations: at any time, a yield curve occupies certain coordinates. As time passes, this curve morphs and changes as trades take place, thus establishing the discounting of each treasury bond. But this passage of time is not displayed along a time axis simply because each yield curve is a snapshot. As Callender correctly surmises, each curve has its own reference to a 'now'. Any discount rate requires indexing via a present.
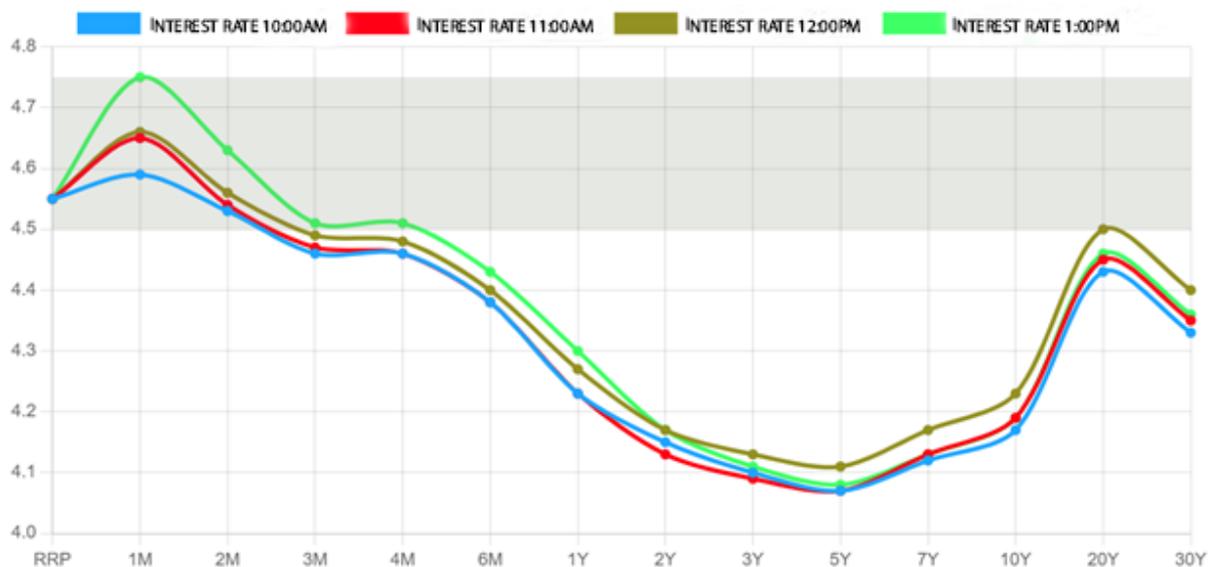

Figure 7: Treasury Bonds Yield Curve in Motion.

In Figure 7, we see that multiple yield curves representing intraday trading. We may interpret this in two ways. The first is that each yield curve is generated 'anew' with

each passing moment, and the second is that the *same* yield curve undergoes various transformations as trading takes place. In my opinion, the more elegant and more heuristically powerful display is the second interpretation: an animated single yield curve that undergoes transformations. This captures the elimination and replacement which takes place with each trade of the previous curve.

The problem with this approach is that, as we covered, these curves are discrete. The snapshot that we typically see requires animation. However, this is obviously compatible with a static framework of the X (interest rate) and the temporal Y (duration until maturity). There is, as trading takes place, another temporal dimension of analysis. This separate dimension of analysis, I suggest, is a good place to start looking for dynamism. Once we do this, the situation represented by Figure 7 starts to look a little bit more like our ice hockey game example. The EPVers would respond to that example by claiming that the process of the game, including the clock, is simply a series of events measured in proper time along a worldline. In such a case, there is not anything problematic about having more than one clock.

My claim, however, is that dynamism is not found in rates *simpliciter* but in the *generation* of rates. In Figure 7 we see rates being generated as time passes. Recall our hurdle however: to claim that a change is 'dynamic', we must be able to answer the question 'dynamic compared to what?' In this section I intend to make good on my promise and give an account of the 'what' the question asks for.

Price's challenge is to find an example that fulfils two conditions. First, it must differ relevantly from his 'miles per miles' example. And second, is self-referential like the rate of seconds-per-second. In my view, the two time-dimensions to which we made reference above do not yet clear the second part of Price's challenge. The EPV response could be, at this point, that this representation does not get at anything over and above the way a clock 'resets' every 24 hours with the passage of a full day. Thus, the heuristic power that I mentioned above is entirely epistemic: it is merely a reflection of the fact that we find ourselves embedded in temporal perspectives, and any discount rate requires indexing via a present (Callender 2017). If this is true, then the only dynamism on the table is that which comes along with this embedded bias. (This suggests the possibility that some animals might share at least some aspects of an A-series-like representation of the world; see Callender 2017, 31.)

All in all, the interpretation of Figure 7 I favoured above does not give us the 'what' demanded by the *non-impredicative TRA*. What we established in the first section of this chapter is that a purely synchronic account of a currency unit like the dollar has a time axis. In Figure 7, the two times being analysed – the trading timeline and the static settlement timeline – are two different things. If there is some 'what' that passes Price's test and is not just another temporal dimension, we need an impredicative dimension of analysis. What must be in motion is the temporal axis compared to *itself*. In the snapshot of each yield curve, we see, with each day's trading, the succession of each temporal axis.
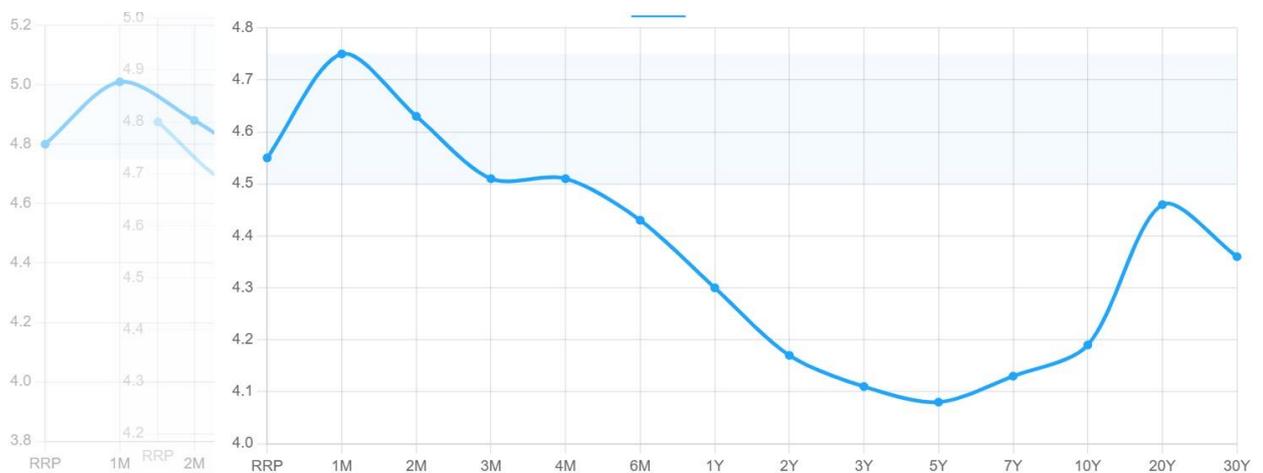

Figure 8: The Scales are in Motion.

Figure 8 bears many similarities to Figure 2, but two important things have changed. The first is the curves themselves, much like what we saw in Figure 7. The temporal axis also appears to be in a state of motion: RRP moves one month at a rate of one month per month, even though it only moves in discrete jumps of one day. What the red line represents is the motion of the zero starting point as represented by RRP along the timeline. The red line indicates the continual translation of the yield curve has time passes. At the same time the yield curve undergoes various transformations due to activity in the market.

As we have already seen, the representation of each subsequent day loses the previous graph's representation of the past. Hence, the yield curve is not time reversal

invariant. Calling the evolution of the system of interest rates from the embedded perspective of the initial yield curve on the far left 'forecasting' can indeed be meaningful. But, if we instead look only at the representation to the right, all previous states are completely obscured. We can bring the future to the present, as it were, but we cannot bring the past to the present.

What the graph in Figure 8 represents, then, is a present that advances or flows or moves into the future. But the EPVer might still be sceptical. They might reply that this representation still lacks an important dimension of analysis. All this graph *really* says is that, during one month, the RRP is at one location, and during another month, it is at a different location. If we want to claim that there is a true, robust flow going on here, we need to compare this change to some other dimension. Hence, while this analysis of Figure 8 still does not give us a precise account of what is dynamic about time, it does tell us where to look: in the scales themselves.

To fully satisfy the demand for a 'what' against which to compare the supposed flow of time, we must return to Bolder. What we have established so far is that a purely synchronic perspective on value of the dollar includes a time axis because you can buy or sell the dollar into the future. We therefore have the building blocks for what Bolder calls 'higher dimensions' (Bolder 2001, 9). We can think of each of these instantaneous evaluations as foliations of yield curves over time. We can also stack up these term structures at a particular instant in time as we model the implications of the underlying expectations. In this way, we can construct an explicit model of the time evolution of interest rates based on the present yield curve. It is important to note that this is not diachronic: such an expectation is built out of, and implied by, the yield curve itself. Since each yield curve is synchronic, so is this representation of the evolution of interest rates.

Term structure is not a scalar quantity, such as the exchange rate or a particular commodity price, but is actually a vector-valued object (Bolder 2001, 2). As a result, the current yield curve does not just tell us about current prices for contracts into the future but also about what we might construe as 'market expectations'. This allows us to generate further simulations of future term structures. According to Bolder, there is more information in the yield curve than what is explicitly plotted. Importantly, if this

information was not present, there would be risk-free profit to be had – hence the no-arbitrage argument.
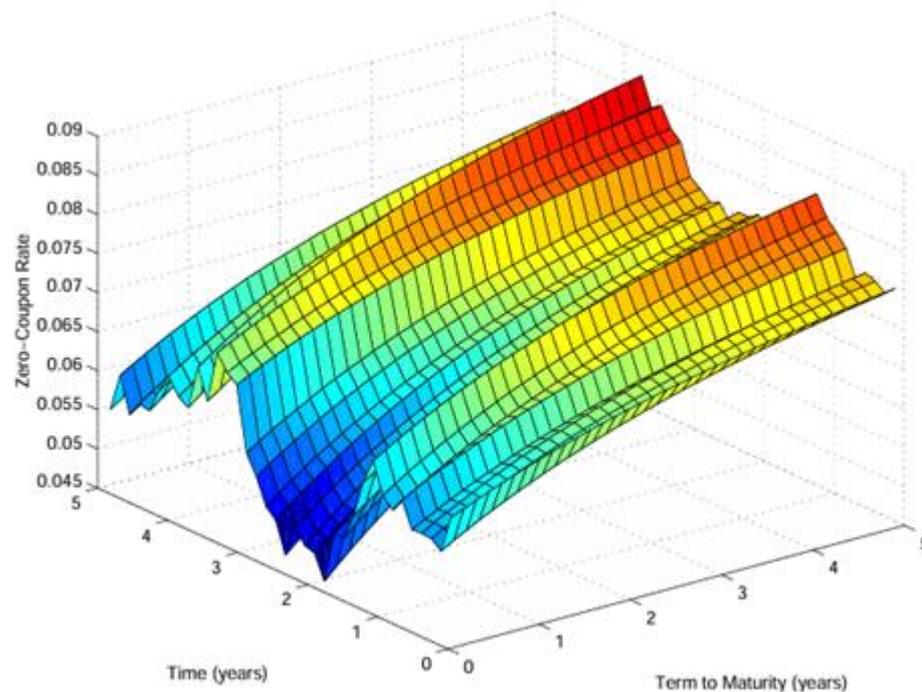

Figure 9: Term Structure dynamics at an instant (Bolder 2001)**.**

Figure 9 represents just such a simulation. We can use the heuristic of an instantaneous short-term rate to construct an additional foliation of interest rates at any given instant. As previously established, term structures in any yield curve consist of interest rates and a temporal axis that represents years to maturity. This temporal axis is indexed to the point in which the dollar is worth a dollar and, as I have argued, this is the point in which the axis of the representation is 'present'. Hence, financial time attributes to the world an objective global 'now', one that divides past from future. Our money practice thus requires what Laurie Paul calls 'a primitive, monadic property of nowness' which is responsible for the origin where the dollar is worth a dollar (Paul 2010, 333). Paul rejects the primitive monadic property of 'nowness', and notes that

> [i]n general, the objection to the parsimonious view of the reductionist is that, without the properties of nowness and passage, we would not have any way to account for the features of our temporal experience. (Paul 2010, 337)

What we can see in Figure 9 is a further time scale that allows for further foliations based on an instantaneous interest rate. For each moment along that term structure at time τ, there will be a yield curve that can be generated at τ with τ as the origin.

In an effort to put this simply, we have terms structures that one can purchase now. Based on these terms structures there are, built into the market, what is often referred to as 'market expectations'. But it is important to note that these are merely a reflection of the present yield curve. This analytic relationship allows for the modelling of instantaneous short-term rates of interest in order to characterise the entire term structure of interest rates at 'any given instant in time'. At each such instant, we can slice across the time axis and recover the cross-sectional term structure of interest rates as though it were indeed 'present'. (We should stress that this is significantly different than an organisation constructing a *pro forma* projection or a five-year plan.)

We can glean a few takeaways from this discussion. First, what characterises any given yield curve is the way it is indexed to the present, even as it abstracts away from particular agents or locations. When the yield curve is 'present', all temporal points along the axis are genuine open opportunities. They represent possible states of affairs. In reality, what is traded is discrete, but these discrete points display vector values very well. Each of these instantaneous points has a distinct set of associated modal facts, but each is still related to the current yield curve. If we take an intentional stance towards the market, we might want to describe it in terms of more than just what current prices are for different term. We might also want to say things like 'the market thinks future yield curves will look like foliations in Figure 10'. This, of course, is to attribute intentionality to the market, but this stance is purely heuristic.

According to Bolder,

[i]n higher dimensions, the instantaneous rate of interest is merely comprised of a linear combination of the multiple underlying state variables. This provides a straightforward algorithm for simulation of the term structure. (Bolder 2001, 9)

As we saw in the case of language, modal facts may be obscured when the temporal horizon is past-facing. These facts, when historical, do not represent full and robust opportunities for action. We may still describe them subjunctively, but we are also apt to describe them historically and diachronically. In the above example, we now have

two temporal axes in a synchronic representation. The above time axes thus represent *the very same thing*. And as a result, time in this representation is orthogonal to itself.

Even though we have two distinct temporal dimensions of analysis, can we describe this as a diachronic analysis? The problem with doing this is that both the trading aspect and the predictive 'what the market thinks' aspect are indexed to the same instant in time – now – when one dollar is worth one dollar. As time passes, we see it is actually the scales themselves that change.
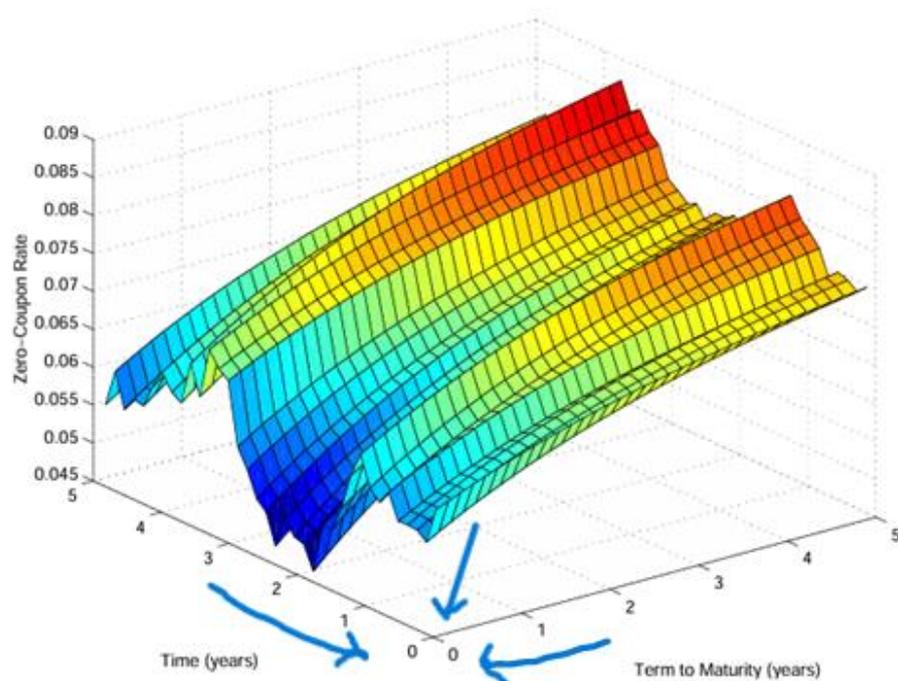

Figure 10: **Term Structure the Scales are dynamic.**

Figure 10 now gives us a representation of where we may look for the dynamism of time. Please pay close attention to the three blue lines. We now have two dimensions of analysis that are the *exact same thing*. As time passes along the axis to the left, time passes along the time axis to the right. The rate at which it passes is one year per year. The coordinate origin represents the instantaneous forward interest rate. Once we have a reasonable way to achieve self-reference, we can obtain an infinite number of dimensions without ontological explosion: they are merely dimensions of analysis. At last, it is the continual shifting of reference frames induced by IRP in this model that constitutes its dynamism.

We started this chapter talking about the 'certain, fixt and immutable' bias. There is no question that Bolder's term structure model spatialises time just as one would expect from any representation of time using a Cartesian coordinate system. This demonstrates dynamism because there is no fixed position in which to make absolute determinations. Further, this vindicates Simmel's assertion that the completely dynamic character of the world is baked into the money practice. The tables are now turned: instead of trying to find dynamism in static representations, it is difficult to find anything static *at all*, except insofar as snapshots are supposed to be static. In Figure 10, there is no fixed Archimedean vantage point outside the money practice. Instead, we have an impredicative, dynamic fulcrum internal to the money practice. This reflects the *impredicativity of totalities*. Once we are at what I referred earlier as the 'zero starting point', the point where one dollar is worth one dollar, there are no more McCall-type branches left to be pruned.

Chapter 7: Conclusion

Money has been a peripheral player in debate over time's flow, but I have argued that it should be taken seriously by bringing the money practice centre stage. What I have established in this thesis is that money is an instance of our measurement practice. The natural consequence of this is that there is a *money hypostasis*: money has some permanent, essential features. It conveys more or less similar effects on social relations, regardless of the society in question. And it does this in a manner compatible with the idea that a society no more must have money than it must employ clocks.

We began with Callender's claim that while money is an invented placeholder for things we value, it is not something we value *in and of itself*. Just as money, we should think of time as an invented placeholder, or so Callender claims. Hence, time, just as money, is a fiction. My strategy was to turn the tables on this argument. Indeed, money is not something that is valued in and of itself – it has no intrinsic value. But then, neither is anything that money measures. This is accounted for with the concept of endogenous value.

Money is an endogenous phenomenon. Its exchangeable value comes not from an external authority but rather from the total field of prices that sets exchangeable value. This includes the buying and selling of itself into the future. Measurement itself is a comparative practice. It always involves an expression of the quantity of a thing 'in terms of something else'. But the mere fact that money has no intrinsic value does little to imply that it is a fiction. By the same token, just because we compare motions with one another using time as an intermediary does not mean that time is a fiction.

This project began with the TRA, the most significant objection to the dynamic view of time. I established that the regress consists of two claims. The proponents of some version of the TRA (Broad, Dunne, Smart, etc.) presume that the rate of time's flow is an absolute quantity (one which it has 'in and of itself') and yet they also claim that it can be deduced only by a relative comparison of time 'in terms of something else'. On this basis, defenders of the TRA claim that if time flows, then there must be a way to sensibly attach a rate to this flow. I take 'attach' to imply that this rate is in principle measurable. This casts the horns of the dilemma into stark relief. On the one hand, time's flow must be an 'in and of itself' sort of motion but this entails that it is 'nonsensible'. On

the other hand, if it is measurable by means of comparison to something else, then it is not an 'in and of itself' sort of quantity. Time must thus be either 'one thing relative to another' or '*sui generis*'.

In this thesis I have established that this argument rests on a mistake. These two ways of looking at time are not mutually exclusive. This becomes clear if we think of time in the same way we think of money – that is to say, it involves a similar kind of self-reference. This is what I call *impredicativity*. Importantly, we established in Chapter 1 that measurement must be relative to some frame. Self-reference is thus part of choosing a frame of reference.

In Chapter 1, I established that time does indeed need a 'rate of flow', and the rate of 'one second per second' fulfils this requirement. Moreover, it does so without reference to another temporal dimension of extension.

Chapter 2 took the analogy with money further. The question asked in Chapter 1 was whether a regress argument sharing its formal structure with the EPV can be constructed for money. An analogy suggested itself: if something flows, it flows at a rate. Similarly, if something is worth something, then it can be exchanged at a rate. But there is an immediate, *prime facie* objection to this latter claim. There seem clearly to be things that people value that they also think are not exchangeable. For example, a human life is often taken to have value, but is also thought not to be exchangeable. This entails that value as such can at times defy measurement. The fact that there are some incommensurable values in fact bolsters my argument. This simply means that there are things we value that defy measurement. The money practice, by contrast, necessarily concerns commensurable values. This is why, in Chapter 2, I examined only the trading practice. I established that exchangeable value fits neatly into the formal structure of the MRA. This implies that money need not have what Callender called a value 'in and of itself'. Note that I do not claim there are no things with intrinsic value. Rather, my point is that the money practice does not *require* intrinsic value. This is precisely why I put aside the *sui generis* way of thinking about the flow of time for this project. I thereby remained true to 'the empiricist loyalty test' by sticking strictly to those values that are epistemically accessible. There is no need for me to appeal to the way a thing may be 'in and of itself'.

There is a problem left unanswered in Chapter 2. In the Maudlin/Price discourse covered in Chapter 1, we saw Price make the important assertion that the thing referred to by each instance of 'second' in the rate 'one second per second' bears the 'very same thing' relation to the other, whereas a dollar does not in the apparently similar rate 'one dollar per dollar'. I called this the 'very same thing' argument. The dollars that are being exchanged thus appear to remain distinct.

Chapter 3 specifically addressed Price's distinction. This required a significant exploration of the ontology of money. What this chapter showed is that the unit of currency 'the dollar' is in fact a unit of measurement, 'the dollar'. Moreover, there are three distinct components of money: money is (i) a human universal that is (ii) instantiated by specific currencies and (iii) tokened by specific objects, such as dollar bills. Price's 'very same thing' argument is not tenable because he conflates the second *qua* token (such as what we obtain in the use any well-functioning clock) and the second *qua* measurement unit. The same sort of abstraction occurs with money. There is the dollar *qua* measurement unit and the dollar *qua* individual money token, such as a bank note or coins. Each individual money token and each individual clock's second do not bear this 'very same thing' relation to any other. What *does* have this property is the currency unit 'the dollar' and the measurement unit 'the second', and each has this property to the same extent. This is the basis for what I refer to as the **impredicativity of rates principle (IRP):** impredicative rates are 'sensible' *iff* the units that the quantities describe are maximally fungible. This means that these units are the 'very same thing'. The problem in the case of money is that, for example, the value of the dollar is in constant flux. It is on this basis that I further asserted the **frame of reference impredicativity principle (FRIP):** fundamental measurement is always frame dependent, where the origin of the frame represents maximal fungibility of the measurement unit. In the case of money, the point at which a dollar is worth a dollar is this origin, and I refer to this as the 'zero-starting point'. Taken together, these two principles allow for impredicative rates and generate no vicious regress.

I argued that money is essentially a measurement that takes place through exchange. This raises a significant problem. Money is synchronically but not diachronically fungible. This constituted what I called the diachronic defeater. Likewise, there is a question of whether each measured instance of a particular unit of duration,

even by a caesium atomic clock, is perfectly commensurable with every other. The fact that we see coordinate time measurements diverge should be taken seriously. This suggests that even for seconds, Price's 'very same thing' claim is untenable. For the dollar, what the diachronic defeater to maximal fungibility says is that, at every moment of evaluation, genuine modal change takes place.

What was discussed in the first four chapters was the TRA. What was not discussed was a far more evasive claim of the TRA, namely the problem of perspective. In the Introduction, I noted that Callender claimed that money is a convenient fiction and, by analogy, so is time. In Chapter 5, I examined a more daunting obstacle: the EPV. The EPV posits that it is perfectly reasonable for creatures with embedded perspectives like us to employ what is commonly called 'manifest time' in our everyday lives without needing to incorporate it into 'scientific time'. 'Manifest time' is the regimented common-sense view that time flows and consists of past, present and future. I anticipated that there would be two probable responses to my view lodged specifically from perspective of the EPV. The first objection is that the money practice I describe is merely a certain historically and culturally contingent kind of money, rather than a universal one as I have claimed. The second objection is that even if money does have the universal features I describe, it remains merely a measurement of our values and biases that emerge from an embedded context of 'manifest time'. I moreover showed that the EPVers has a hard time avoiding what I call the Moorean contradiction.

My response to the first objection directly leads to my response to the second objection. First, money cannot function any other way than it does, simply because of the sorts of creatures we are. Furthermore, we are the sorts of creatures we are because we are IGUS. This claim is also able to answer the second objection, in precisely the same way. We as individuals are IGUSs, and this has implications for the ontology of social institutions: social institutions such as money, economies and science itself are all IGUSs. What Chapter 5 showed was that the IGUS framework is applicable to similar sorts of institutions. When money is conceived as part of an economic IGUS, this IGUS is spatially but not temporally allocentric. The IGUS that is our institution of scientific practice shares the same limitations. I therefore challenged the supremacy of 'physical time' (the time studied by physics), because scientific time does not reduce to physical time. Instead, I argued that scientific time spans all domains of science. The concept of

time involved in the processes and practical applications of the scientific method is also part of scientific time.

All this being said, we still need to account for dynamism. Here too I turn the tables. In Chapter 6, I asked what we could compare this thing called 'Minkowski spacetime' with to declare that it is unchanging. Here, I agree with Price. According to him, '[t]ime is supposed to be included in the block, so it is just as wrong to call it static as it is to call it dynamic or changeable' (Price 1997, 13). This is true if we analyse time as 'one thing relative to another'. But just as in the case of money, there is also an 'in and of itself' level of analysis. Here I again suggest that looking back to Barrow provides helpful insights. He makes the same sort of distinction with respect to time as Price, but he also allows for the '*sui generis'* analysis as well, claiming 'that time implies motion to be measured' (Barrow 2008, 35). He also writes that 'you may perhaps wonder why I explain time without motion, and will say, does not time imply motion? I answer no, as to its absolute and intrinsic nature, any more than it does rest' (Barrow 1735, 6). I think that Barrow made the same point that Price made.

As Price says, we should think of time as being in the block. But if we do this, we must also figure out what sort of explanation an 'Archimedean' viewpoint, one which has some fixed point of analysis, gives us. Here I turned to Jenann Ismael. As she proposed (correctly I think), adopting a transcendent perspective makes sense in physics, at least as a heuristic. From such a perspective, we look down on this manifold with (perhaps) unchanging laws as the fulcrum. An attempt to analyse money, however, yields an entirely different sort of 'Archimedean' perspective. This is the one offered by Simmel: it is only because reality is in constant motion there any sense in asserting its opposite. Money, by its very nature, is in constant motion. What Chapter 6 showed is that in the representation of money and yield curves, there is nothing that in the final analysis can be described as 'static'. It is important to note that yield curves do not represent the past at all. In the static view, the time scales are not supposed to move. All motion is supposed to be contained in the graphs plotted on the scales. But this representation is inadequate, a we are left trying to represent dynamism using something that can only be static graphs. To the extent that a static image can convey or represent motion, these graphs do. In a yield curve, even the scales or axes are in motion. Just as importantly, we can postulate multiple time-dimensions without generating a vicious or explosive ontological regress.

In Chapter 6, I was careful to treat the fragmentalist view as distinct from the EPV, even though it is a 'perspectival' view and shares common ground with traditional B-theory. I think that fragmentalism enjoys advantages over the EPV. The fragmentalist is able to give an account of flow in terms of narrative or storytelling, and this seems to be a need that we, as IGUSs, have. Fragmentalism has an important insight, which I share: from the perspective of each moment, time's flow is a coherent order. From a global, Archimedean perspective, the fragmentalist thinks that flow is an incoherent amalgamation of incompatible facts. We arrive at an analogous situation when we think of the dollar being worth a dollar. What I am defending, however, and what is missing from fragmentalism, is a dynamism of flow. It is nonetheless worth restating that neither fragmentalism nor was *strongly timeless* anti-realist approaches in the Paramedian tradition were the primary target of my criticism. Those with B-theoretic deflationist sympathies can reconcile their views with what I have claimed by considering fragmentalism.

Where this leaves us is that the measurement practice itself, as I argued, seems suspect. Measurement requires a vantage point of stability, but this seems unobtainable. We might well be able to say that a caesium atomic clock gives a highly accurate, invariant measurement of a particular path through spacetime, but this involves the assumption that all similar intervals in the measurement are of equal extent. Relativity theory does not allow us to make such a claim. *Any* path through spacetime can have regions of time dilation and length contraction. Such a clock may say something objective, but it does not seem foundational. What the money example shows is that measurement does not seem to be the right sort of concept to sit at the bottom of physics.

As I have argued, time, like money, is impredicative: it is self-measuring. Just as money is defined by money, time is defined by time. Even though, as Ismael argues, the adoption of a transcendent perspective is often warranted in physics, our measurements seem ill-fitted for that purpose. So why was measurement supposed to be such a big problem according to the TRA? No one thinks that if something *is not* flowing, we must posit another time-dimension to determine if it is really staying put. What the money example shows is that *nothing* stays put, including perhaps the laws themselves. The main take-away from all of this is that underlying money's measure of exchangeable

value is the idea of value 'in and of itself'. Not all the things we value are exchangeable. This is like time's flow in being a unique or *sui generis* process. Do not ask the measurement practice to do what it cannot do.

Appendices

8.1 A, B, C and Ds of time.

Since J. M. E. McTaggart's notorious argument for the unreality of time, various degrees of anti-realism about time have come to be designated by the letters A, B. C and D. The idea is that certain properties of time are nested within other properties. A D-theory of time can be described as genuinely anti-realist about time. A C-theory, on the other hand, is realist with respect to time having dimensional features. B-theory adds still another realism: time now has both a dimension and a direction. And at the top of the heap sits the A-theory: time has dimension, direction, *and* flow. McTaggart argued that in order to get a B-series (and hence B-theory) of time, one needs a direction of time. Such a direction then requires an A-series of time (one with past, present and future). However, A-properties are contradictory: every moment in a temporal series is at one time both past, present and future. Because A-properties are incoherent, so too are directional properties. McTaggart concludes that C-properties are the only properties that time could possibly have, but dimension is not sufficient to give rise to full-blown time.

8.2 'Allocentric' versus 'egocentric'

Egocentric representations of time and space derive simply from of our embedded perspective. They are determined by indexical locutions such as 'here' and 'now'. We nonetheless easily acquire an allocentric view of space, because we interact with other people who have egocentric views of what constitutes 'here' which all differ from our own. Strangely, however, we all seem to share the same egocentric perspective on 'now'. 'Manifest time', the regimentation of our common-sense view of time, is allocentric about space. We don't think there is a global 'here', but we are egocentric about time because we all think we share the same 'now'. As a result, we are prone to mistaking this 'now' for an objective property of the world – or so those who deny a true distinction between past, present and future would have us believe.

8.3 'Dimensionless'

Price claims that rates are a dimension of analysis. What this means is that they are expressible as units in some system. They can fit on a scale or axis of analysis. For example, the dimension of speed can be expressed in units of km/hr, from 0 onwards. He argues that if a rate does not scale in this way, then it is either not a rate (and the flow of time must be expressible as a rate), or not the right sort of rate. According to Price, a dimensionless quantity is not a rate *at all* (Price 1997, 13). Based on this, the types of units the quantity in the numerator position has must be different than those the quantity in the denominator position has. It is worth looking at other disciplines which consider dimensionless quantities.

'Dimensionless quantities have no dimensions and units but have a physical meaning. A dimensionless quantity is a ratio of quantities having the same dimension. They are also recognised to be unitless quantities, provided that quantities in the ratio have consistent units. It is an advantage to use dimensionless quantities since they have always the same value without considering the units used as far as they are consistent' (Jafari 2021, 35).

There is an important caveat that needs to be recognised when we use the word 'dimension': the word 'dimension' refers to a measurable physical quantity.

8.4 'Embeddedness' as per the Embedded Perspective View.

Organisms like humans find that we are embedded in a thermodynamic world, which gives rise to certain perspectives on time. We have access to memories of the past but not the future. The embedded perspective takes seriously two temporal asymmetries described by Paul Horwich (Horwich 1987): the knowledge and decision asymmetries.

8.5 Epistemic versus ontological openness

The key difference between epistemic and ontological openness is that epistemic openness merely reflects changes in beliefs. It is a type of variation of 'one thing relative to another.' Ontological openness means that all change is McTchange.

8.6 Indexicals

An indexical is, roughly speaking, a linguistic expression whose reference shifts from one context of utterance to another. 'Here', 'now', 'I', 'you', 'today', etc., are all indexicals.

8.7 Flow

When we apply flow in a quotidian way, we ascribe certain properties to the thing being described. Generally, when we say that something flows, we expect a speed, at least one or more directions, or some kind of potential difference (such as voltage or water pressure). We also expect connectivity and continuity. A river, for example, does not have any gaps. We also say that a well-written novel or essay flows. When something flows, its parts seem to connect well. I hope that this thesis flows.
Electricity flows through a continuous series of connected wires, but it is hard to pin down what precisely is flowing. Whatever it in fact is, we can determine velocities of electrical transmission. Money also flows through an economy. But we cannot make a comparison between time and time in the same way. For our purposes, Ned Markosian offers a good formulation of what he calls **The Passage Thesis**: See below.

8.8 Gresham's law

The short definition is 'bad money drives out good". Given a choice, in an economy, participants will sort there money based on a variety of factors. When two forms of

money are legally treated as having the same value, people tend to spend what they perceive as the lower-quality money (the "bad" money) and save or hoard the higher-quality (the "good" money), so the good money disappears from everyday circulation. Quality in this context might refer to scarcity, wear and tear, attractiveness or metal content.

8.9 Impredicativity

Impredicativity refers to objects that are defined by quantifying over a totality that includes the object itself. Impredicativity is a term used more commonly in logic and mathematics. It names a kind of circularity. In classical set theory, impredicative definitions arise when a set is specified by a property that ranges over all sets, including the very set being defined—for example, defining a set as "the set of all sets with property P," where the domain of quantification already presupposes the completed universe of sets.

This feature was central to early foundational debates: while systems such as naïve set theory allowed unrestricted impredicativity (leading to paradoxes like Russell's), later axiomatic frameworks sought either to restrict or carefully regiment impredicative constructions.

Philosophically, impredicativity can be illuminated using the notion of direction of fit. In a predicative definition, the direction of fit runs from the defining conditions to the object defined: the definition builds the object using only prior or simpler elements. In an impredicative definition, by contrast, the direction of fit is bidirectional: the object must already be counted as part of the totality in order for the definition to succeed. Impredicativity philosophically contentious but also conceptually powerful as the money practice illustrates since it enables definitions that capture global structural properties that cannot be recovered through strictly bottom-up, predicative means.

8.10 'Manifest' Time

'Manifest' time is a regimented common-sense image or conceptualisation of time. 'Manifest' time is used in contrast to the 'scientific' image of time. Both of these expressions have their origin with Wilfred Sellars (Sellars 1962). Sellars' idea was that the 'manifest' image precedes the 'scientific' image but cannot be wholly replaced by it. The 'manifest' image is the way things appear or seems to us. Sellers claims that there is an irreconcilable conflict between these two images. This irreconcilability is particularly apt in the case of the 'manifest' image of time. 'Manifest' time has two important apparent features that supposedly distinguish it from 'scientific' time: it appears to flow, and it appears to be divided into past, present and future.

8.11 McTchange

McTchange is a robust, mind-independent change in what is present. This terminology was introduced by Graeme Forbes. It is useful to distinguish the typical A-theorist's concept of change from the B-theorists' concept of change: '[c]rucial for McTchange is that change, in this sense, is not relative to anything else. It's not that a proposition is true at time t, and false at time t' (that would just be a mere temporal variation), but that the proposition changes truth-value simpliciter' (Forbes 2025, 4). As Forbes describes, if we were to give an account of everything that exists, that account would change over time (Forbes 2015, 188).

8.12 Money Hypostasis

In this thesis, I use 'money hypostasis' to refer to features of money that remain constant across cultures and over time. I argue in this thesis that money, particularly the abstract units commonly traded in modern societies, is in essence quantitative, abstract and homogeneous. Currency units should be portable, divisible and durable, and are manifested by commodity exchange. Economists tend to think that there are such enduring features of money. Critics of money hypostasis tend to look to anthropological evidence that money has no permanent features but is rather always socially contingent. Disagreement over money hypostasis often mirrors disputes over how universal 'manifest' time is.

8.13 Rates

Part of the goal of this thesis is to answer the question 'What is a rate?'. We can get some purchase on it by first looking at how we go about ascribing rates. Rates are a type of ratio but just constitutes the distinction between rates and ratios is not straightforward. One thing seems clear, however: rates are part of our measurement practice. Jonathan Tallant provides a nice summary of how we apply this concept. He thinks there are three distinct reasonable ways in which we talk about rates and a fourth one that is questionable (Tallant 2016, 41).

8.14 'Sensible'

Throughout this thesis I apply Price's criteria for what sorts of accounts are 'sensible': 'Well, the stock objection is that if it made sense to say that time flows then it would make sense to ask how fast it flows, which doesn't seem to be a sensible question' (Price 1997, 13). The argument seems to run this way: the concept of time's flow is of no use to us whatsoever; hence it has no sense, and is therefore completely redundant.

For Price, 'sensibleness' is about the capacity to make sense, to be meaningful. The idea seems to be that, since the question of how fast time flows is incoherent, the question itself is incapable of any meaningful answer. In this thesis, I accept the need to clear this sense-making hurdle. This is a lower standard of assertability then being justified: I can talk meaningfully about things that I am not justified in believing. However, I will argue is this thesis that time flows, that we can make use of this concept, there is some sense to it, and it is therefore not redundant.

8.15 'Synchronic' and 'Diachronic'

The distinction between synchronic and diachronic analysis has its origins in linguistics. This distinction was first introduced by Ferdinand de Saussure (Saussure 2011). A synchronic analysis of language deals with the state of a language and the linguistic community at a particular point in time.

The important take-away here is that a synchronic analysis is a study of a fixed phenomenon existing at a given moment. This does not mean that time is irrelevant to a synchronic analysis. To the contrary: at any moment, there are many true and false tensed statements. In this respect there, is still a horizon of temporality. Nonetheless, analysis pertains to one specific time slice.

A diachronic analysis, on the other hand, concerns changes in a system, whether of language, beliefs, dispositions or their expression in social institutions such as the money practice. Built into such an analysis is evolution over time. There is a horizon of temporality as conceived as the duration over which a system is being analysed.

In this thesis, I extend this distinction to the process of analysis itself. This is a reasonable consequence of having an embedded perspective. I will argue that diachronic analysis is the same thing as historical analysis.[114] Likewise, I will argue that it is inappropriate to apply diachronic to future forecasting. This will be covered in more depth in Chapter 4.

8.16 Temporal Decentring

Temporal decentring is the process of trying to be allocentric about time in the same way that we are allocentric about space. This presents problems for our money practice. Money has no problem being spatially decentred, but cannot be temporally decentred.

8.17 Temporal Discounting

In economics, **temporal discounting** is usually analysed as a preference structure governing how agents trade off value across time, but an important distinction is often drawn between *proximal–distant* discounting and *past–future* discounting. Proximal–distant discounting concerns temporal distance as such: outcomes that are nearer to the present are weighted more heavily than those further away, regardless of whether they lie in the past or the future.

Past–future discounting, by contrast, reflects an asymmetry in how agents treat temporally distant events depending on their temporal direction, with future

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[114] According to Judy Pearsall, '[i]n modern references, the term "historical" is often used interchangeably with "diachronic". The term "historical" to refer to dictionaries on historical principles emerged before the distinction of "diachronic" and "synchronic" was formalized by early twentieth-century linguistics' (Pearsall 2020, 31). While there aren't significant consequences to this approach in linguistics, there are when one takes this approach to finance and the money practice.

outcomes typically discounted more steeply than past ones. Standard economic models largely focus on future discounting, since only future goods and harms are action-guiding, and they formalize this asymmetry using discount functions that reduce the present value of future utilities while treating the past as fixed and normatively inert. This raises a measurement question. If the past is normatively inert then how can we measure past discounting? One strategy is to simply ask people their preferences in counter-factual or subjunctive terms.

Another important distinction is drawn between *monetary discounting* and *pure discounting*. Monetary discounting reflects instrumental considerations such as opportunity cost, investment returns, inflation, and risk: a dollar available now can be productively invested and is therefore rationally preferred to the same dollar received later. Pure discounting, by contrast, involves discounting value solely because it lies in the future, independent of uncertainty or foregone investment opportunities. Pure discounting is ethically controversial because it expresses a normative preference for temporal proximity itself, treating future welfare as intrinsically less significant than present welfare.

8.18 The Passage Thesis

The passage thesis says that '[t]ime is unlike the dimensions of space in at least this one respect: there are some properties possessed by time, but not possessed by any dimension of space, in virtue of which it is true to say that time passes' (Markosian 1993, 830). To be clear, I am defending the passage thesis.

8.19 The Zero Starting Point

A 'zero starting point' represents a point in a ratio scale in which the variable being analysed has a quantity of zero. For our purposes, the critical variable is duration. Therefore, when we discount money, we begin at a 'zero starting point' in which there is no duration.

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