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Doctoral Thesis

Essays on Labour Market Fluctuations in Emerging Market Economies

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Declaration of Authorship

I, Sevgi COŞKUN, declare that this thesis titled, 'Essays on Labour Market Fluctuations in Emerging Market Economies' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
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Abstract

The goal of this dissertation is to contribute to the literature on labour market properties of business cycle fluctuations for emerging market economies (EMEs) by using DSGE modelling and time series analysis. It consists of three essays and the following related topics are analysed.

In the first paper, entitled ***"Labour Market Fluctuations: An RBC Model for Emerging Market Economies"***, we examine the labour market properties of business cycle fluctuations for a group of 15 EMEs and the US using annual data from 1970 to 2013. We find that on average, hours worked and employment volatility (relative to output volatility) are lower, while the volatility of productivity and wages are 2-3 times higher in EMEs than in the US. We then assess the performance of a standard RBC model with temporary and permanent productivity shocks to explain those facts observed in the data. We find that this model can account reasonably well for the relative volatility of hours to output; however, it fails to capture for the rest of the relevant moments for EMEs. In order to further improve the fit, we augment this model with capacity utilization, investment adjustment cost and indivisible labour. We find that each of these extensions improves the capability of the RBC model. Especially the model with investment adjustment cost improves its performance regarding the relative volatility of wages and hours, as well as the cyclicality of hours, compared to the standard RBC model. Lastly, we investigate the cyclical properties of the labour wedge (the wedge between the marginal product of labour and the marginal rate of substitution of consumption for leisure) and find that the total labour wedge (relative to output volatility) is more volatile over the business cycle in emerging economies (1.72) compared to the US (0.95). Further, fluctuations in the total labour wedge reflect the ones in the household component rather than the firm component of the wedge in EMEs and the US.

In the second paper, entitled ***"Technology Shocks, Non-stationary Hours in Emerging Countries and DSVAR"***, we test a standard DSGE model on impulse responses of hours worked and real GDP after technology and non-technology shocks in EMEs. Most dynamic macroeconomic models assume that hours worked are stationary. However, in the data, we observe apparent changes in hours worked from 1970 to 2013 in these economies. Motivated by this fact, we first estimate a SVAR model with a specification of hours in difference (DSVAR) and then set up a DSGE model by incorporating permanent labour supply (LS) shocks that can generate a unit root in hours worked, while preserving the property of a balanced growth path. These LS shocks could be associated with very dramatic changes in labour supply that look permanent in these

economies. Hence, the identification restriction in our models comes from the fact that both technology and LS shocks have a permanent effect on GDP yet only the latter shocks have a long-run impact on hours worked. For inference purposes, we compare empirical impulse responses based on the EMEs data to impulse responses from DSVARs run on the simulated data from the model. The results show that a DSGE model with permanent LS shocks that can generate a unit root in hours worked is required to properly evaluate the DSVAR in EMEs as this model is able to replicate indirectly impulse responses obtained from a DSVAR on the actual data.

In the last paper, entitled ***"Informal Employment and Business Cycles in Emerging Market Economies"***, we examine the relationship between informal employment and business cycles in EMEs and investigate how informal employment is relevant in shaping the aggregate dynamics in these economies. The key features of stylized facts from our data is that it is countercyclical in Mexico, Colombia and Turkey but procyclical in South Africa. In addition, informal employment is negatively correlated with formal employment in Mexico but positively correlated in Colombia, South Africa, and Turkey. To account for these empirical findings, we build a small open economy model with both formal and informal labour markets, and it subjects to stationary and trend shocks to total factor productivity. We also allow labour adjustment costs in the model as strict employment protection which differ among these economies. We then examine the effect of changes in the degree of employment protection on the informal employment and the business cycles in EMEs and the extent to which the informal sector acts as a buffer in the face of adverse shocks to the labour market. The results show that this model can capture some key stylized facts of the labour market in these economies and that the informal sector acts as a propagation mechanism for these shocks. Moreover, informal employment acts as a buffer as it is countercyclical while formal employment is pro-cyclical in the model which supports the results from the data except South Africa. Regarding volatilities, informal employment does not act as a buffer since formal employment is more volatile than informal employment in the model which contrasts with the evidence in the data for these economies except Colombia.

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Introduction

This dissertation is collection of three essays. While the issues analysed in each of paper are somehow different, they share similar motivation.

Emerging market economies (EMEs) differ in many dimensions when compared with advanced economies: (1) they show excessive volatility of consumption relative to output as well as higher output volatility and stronger counter-cyclicality of the trade balance (2) they have a large informal labour market. Based on these observations, these three essays are then an attempt towards closing a gap in the literature by using the DSGE modelling and time series analysis for these economies.

In the first paper, we examine the labour market properties of business cycle fluctuations for a group of 15 EMEs and the US using annual data from 1970 to 2013. We find that the average volatility of wages and productivity relative to output volatility in these countries is about 2-3 times higher than that of the US. We also find that the correlations among employment, hours worked per employed and total hours worked with output in EMEs are much lower than in the US. Furthermore, we assess the performance of a standard RBC model and an augmented RBC model with capacity utilization, investment adjustment cost and indivisible labour with temporary and permanent productivity shocks to explain those facts. The results show that our models can account reasonably well for the relative volatility of hours worked to output whereas they fail to generate the high volatility of wages in EMEs. We also find that a simple RBC model performs poorly to explain most of the relevant second moments for emerging economies; however, the model with real frictions improved the capability of the RBC model. Especially the model with investment adjustment cost does a better job than the other models of matching the relative volatility of wages and hours, as well as the cyclicality of hours. We lastly investigate the cyclical properties of the labour wedge (the discrepancy between a representative household's marginal rate of substitution between consumption and leisure and the marginal product of labour). We find that the total labour wedge (relative to output volatility) is more volatile over the business cycle in EMEs compared to the US and that fluctuations in the total labour wedge reflect fluctuations in the household component rather than the firm component of the wedge in all these countries.

In the second paper, we test a DSGE model using Indirect Inference on impulse responses of hours worked and real GDP after technology and non-technology shocks in EMEs. The problem is that many dynamic macroeconomic models assume that hours worked are stationary. However, we observe that hours worked are non-stationary during the past four decades in these economies. Therefore, any model has to be consistent with the feature of the actual data. Motivated by this fact, we first analyse the effect of technology and non-technology shocks on hours and real GDP in a DSVAR. As a data generating process, we then set up a DSGE model by incorporating permanent labour supply (LS) shocks that can generate a unit root in hours worked, without violating the balanced growth hypothesis. These LS shocks could be associated with very dramatic changes in the structure of labour markets in these economies, which can account for permanent shifts in hours worked, especially the changes in female labour force participation. Hence, the identification restriction on both models is that only LS shocks have a permanent impact on hour worked. We then compare the accumulated responses based on the actual data to the ones from DSVARs run on the simulated data from the model. The results show that hours worked increases permanently after a positive LS shock in EMEs and this model can mimic well impulse responses from a DSVAR on actual data, though not statistically significant in the long run.

In the last paper, we examine the relationship between informal employment and business cycles in EMEs and investigate how informal employment is relevant in shaping the aggregate dynamics in these economies. Our empirical analysis shows that informal employment is countercyclical in Mexico, Colombia and Turkey but pro-cyclical in South Africa. In addition, it is negatively correlated with formal employment in Mexico but positively correlated in Colombia, South Africa, and Turkey. We then build a small open economy model with both formal and informal labour markets to account for these facts, and this model subjects to stationary and trend shocks to total factor productivity. We also allow labour adjustment costs in this model as strict employment protection which are different among these economies. We then examine the effects of changes in the degree of employment protection on the informal employment and the business cycles in EMEs and the extent to which the informal sector acts as a buffer in the face of adverse shocks to the labour market. The model is calibrated to the EMEs, in particular to business cycle moments for informal employment obtained from our calculations. The results show that this model can capture some key stylized facts of the labour market in these economies and that the informal sector acts as a powerful propagation mechanism for these shocks. We also explore that informal employment acts as a buffer in formal sector regarding correlations because we find that, in the model, informal employment is countercyclical and formal employment is pro-cyclical which supports to the findings from the data except for South Africa. Regarding volatilities, we find that formal employment is more volatile than informal employment in the model.

It shows informal employment does not act as a buffer which contrasts with the evidence in the data for these economies except for Colombia.

Chapter 1

Labor Market Fluctuations: An RBC Model for Emerging Countries

1.1 Introduction

In developed markets, the quantitative analysis of business cycle fluctuations has long been of interest to researchers since the work of Kydland and Prescott (1982).[1] It has been found that hours worked fluctuate more than productivity, as this is almost as volatile as output. Labour productivity and employment are more volatile than real wages. Such analysis is also an old issue for emerging market economies (EMEs), but it has only recently been revived within equilibrium business cycle models. It is well known in the relevant literature, where the frictionless real business cycle (RBC) model has received considerable attention as being incapable of replicating the second moments of labour market dynamics; however, it tends to perform well in explaining a good portion of aggregate fluctuations such as output, consumption and investment.[2] Most analyses have focused on developed countries, predominantly on the US, while other markets in the economy have remained unexplored. The aim of this paper is first to explore the labour market properties of business cycles using annual data from 1970 to 2013 in EMEs and then to investigate whether a set of variants of the standard RBC model for the labour market is able to address the features of these economies. Last, we examine the cyclical properties of labour wedge (the discrepancy between a representative household's

[1] See also Backus and Kehoe (1991), Stock and Watson (1999) and Ohanian and Raffo (2012).

[2] These have then led to a whole branch of the literature addressing these problems by introducing matching frictions. See Christiano and Eichenbaum (1992), Hansen and Wright (1992), Fairise and Langot (1994a) and Fiorito and Kollintzas (1994). These studies present some basic stylized facts of labour dynamics (such as productivity and hours worked) and find that the standard RBC model cannot account for these facts in the US and G7 countries.

marginal rate of substitution between consumption and leisure and the marginal product of labour) in emerging countries.

The interest in this topic has been spurred on for several reasons. First, aggregate fluctuations in EMEs are different from those in developed countries. Business cycle fluctuations in these economies are typically more frequent and higher as they are hit by many different shocks compared to developed countries.[3] For example, in emerging economies, output is twice as volatile as it is in developed countries, and, wages are highly volatile and pro-cyclical. Moreover, the variability of employment in emerging countries is about half the variability of output.[4] Motivated by the fact that labour market variables in these economies differ in non-trivial ways from those observed in developed countries, we believe that RBC models provide a useful theoretical benchmark for evaluating labour market fluctuations in the business cycle of emerging countries.

Second, emerging economies differ in their labour market institutions, such as flexibility in contracts, employment protection, firing and hiring costs, the unions, wage rigidity, informal sectors, social protection and unemployment benefits in these countries are quite different from those in developed countries.[5] In the literature, these differences have been proposed as potential explanations to understand the differences between emerging and developed countries in the performance of labour market dynamics over the business cycle. For example, Lama and Urrutia (2011) present business cycle properties and employment protection in developed and emerging countries and show that EMEs face more restrictive labour regulations and less employment volatility relative to output since excessive labour regulation limits the process of adjustment of employment in response to shocks.[6] Moreover, labour market institutions differ greatly among EMEs but less than they vary among developed countries (see Freeman (2009)). Hence, we believe that our study is an important exercise for seeking whether the labour market properties of business cycle fluctuations are alike within emerging economies in our sample despite institutional differences.

Finally, the stylized facts of the labour market in EMEs are not as well known as those in developed countries, and there is no consensus on these economies. Agenor, McDermott, and Prasad (2000) and Male (2010) have pointed out that the results depend on which countries are included in the analysis, as Rand and Tarp (2002) have shown that

[3]The seminal paper- Agenor, McDermott, and Prasad (2000)- present the main stylized facts of macroeconomic fluctuations (output, interest rate, wages, etc.) for a group of 12 emerging countries.

[4]For details, see also Boz, Durdu, and Li (2009a), Li (2011), and Altug, Kabaca, and Poyraz (2011). These papers document the business cycle properties of key labour market variables for emerging market economies, such as wages, hours worked, and unemployment, and compare them to those of developed countries.

[5]See Freeman (2007), Freeman (2009) and Campos and Nugent (2012).

[6]Also, many other researchers have argued that institutional rigidities affect labour market variables in response to macroeconomic shocks, because of the imperfect adjustment of employment and real wage. See Nunziata (2003), Rumler and Scharler (2011) and Gnocchi, Lagerborg, and Pappa (2015)'s work. Note that these papers focus on developed countries.

the stylized facts of business cycles across emerging countries are more diverse than those of the developed countries. We recommend that further research of these economies is undertaken.[7] It is important to ensure that the stylised facts are as accurate as possible since they are a crucial basis for the construction of a model. In contrast to earlier studies, we are able to examine labour market fluctuations in a number of dimensions for a much larger sample of EMEs since we have sufficient annual data for our sample countries as can be seen the sample lengths in the Appendix 1.B.[8]

In the first part of this paper, we systematically document some stylized facts of the labour market properties of the business cycle in EMEs for the period 1970-2013. Then we compare the results with available features of the business cycles in 15 emerging countries with the US. The results are based on co-movements and relative volatilities in employment (the extensive margin), the hours worked per employed (the intensive margin), the total hours worked, productivity, and real wages with output for a large sample of EMEs. The data we collected shows that the average volatility of wages and productivity relative to output volatility in emerging countries is about 2-3 times higher than that of the US. In relation to analyzing labour markets, Li (2011) presents cyclical wage movements in emerging countries and finds that the volatility of wages relative to output in EMEs is almost twice as high as that in the developed economies, and real wages are positively correlated with output. Also, Agenor, McDermott, and Prasad (2000) present pro-cyclical wages for emerging countries. Our results are consistent with those papers, even though there are some differences in the country-level analysis. Moreover, fluctuations of the extensive margin (0.55) are mostly responsible for fluctuations in the total hours worked (0.64) in these economies, rather than fluctuations in the intensive margin (0.26). Another important finding of this study is that the correlations among employment, hours worked per employed and total hours worked with output in the US are much higher than in EMEs, whereas there are no significant differences in the cyclicality of real wages and productivity between emerging economies and the US.[9] These results reveal that the labour markets in EMEs adjust more through prices, while the quantities are subdued.

[7]Note that the literature on business cycles in emerging countries places significant emphasis on explaining output, current accounts, consumption, investment, trade balances and interest rates but much less emphasis on labour market dynamics because of the limited data availability. These stylized facts have examined in the context of models that allow for changes in trend productivity (Aguiar and Gopinath (2007), Garcia-Cicco, Pancrazi, and Uribe (2010)), financial frictions (Neumeyer and Perri (2005)) and search and matching frictions (Boz, Durdu, and Li (2009a)). These papers do not focus on labour markets per se but present some labour market statistics in emerging countries as well.

[8]Backus and Kehoe (1991) also use annual data to study the fluctuations in output, prices and money in developed countries. Typically, the standard business cycle analysis uses quarterly data, but we use annual data, since hours worked data is available only with annual frequency from emerging economies. Using annual data in the business cycle may not capture short-term dynamics, but it is still useful since it preserves medium term dynamics.

[9]See Fang and Rogerson (2009) and Altug, Kabaca, and Poyraz (2011), who present a quantitative assessment of extensive and intensive margins in G7 countries and emerging countries using annual data, respectively. We have slightly obtained different results from those studies.

Motivated by these stylized facts, we then investigate whether a set of variants of the RBC model, with no nominal rigidities, can reproduce the labour market features observed in the data from emerging countries. We first look at the performance of the most standard frictionless RBC model as a benchmark model, driven solely by permanent and temporary productivity shocks, as in Aguiar and Gopinath (2007).[10] They introduce a simple RBC model with trend productivity shock and find that this model can account well for business cycle properties in emerging economies. For this model, we use both separable and non-separable utility functions to determine whether our results are sensitive to the choice of preferences in our analysis. In the data, we observe that the behaviour of labour market variables in emerging economies differ from each other. On average we find that a frictionless RBC model with temporary and permanent shocks does a good job of matching the relative volatility of hours worked in emerging countries; however, it fails to capture for the rest of the relevant moments in our analysis.

In order to further improve the fit, we introduce an RBC model augmented with capacity utilization, as in Greenwood, Hercowitz, and Huffman (1988a), investment adjustment costs, as in Christiano, Eichenbaum, and Evans (2005) and indivisible labour, as in Hansen (1985).[11] Burnside and Eichenbaum (1994) find that allowing for capacity utilization in RBC model magnifies and propagates the effects of the shocks over the business cycle. The intuition behind this, a positive technology shock increases output and capacity utilization generates an additional increase in output amplifying the initial effect of the shock. Our results show that this amplification allows an RBC model with this mechanism to generate hours volatility very similar to the data with much smaller shocks, whereas it decreases significantly the ability of the model to produce the relative volatility of wages and productivity for these economies, compared to the standard RBC model. In addition, we find that the RBC model with investment adjustment costs performs better than the simple RBC model for the relative volatility of wages and hours, and for the correlation between hours and output. This mechanism into the RBC model prevents investment quickly responding to change in economic conditions as it mitigates the effect of shocks on capital stock. Hence, hours worked fluctuate less than wages and productivity. The intuition behind this finding might be as follows. Albonico, Kalyvitis, and Pappa (2012) explain that the negative impact of adjustment

[10] These shocks have been extensively studied in the literature since then. They interpret the shocks to the trend growth as dramatic changes in institutions and policy in emerging countries. See also Chang and Fernández (2010). Note that Aguiar and Gopinath (2007) do not attempt to match the dynamics in hours or employment in emerging countries.

[11] There has been a substantial amount of research that the standard RBC model has been criticized due to its inability to explain some key aggregates variables. See Mendoza (1991), Burnside and Eichenbaum (1994), Cogley and Nason (1995), and Boileau and Normandin (1999). These studies have found that allowing for real frictions improved the ability of the model to account for some features of the data.

costs on hours is amplified by the wealth effect in preferences, as households increase their consumption and decrease their labour supply.

In these models we can see hours as employment only where employment is perfectly divisible. However, the data show that changes in the total hours worked can be mostly attributed to fluctuations in the extensive margin rather than in the intensive margin in these countries. As the final extension, following Hansen (1985),[12] we build an RBC model with indivisible labour. This model has a special feature where all of the variations in labour reflect adjustment along the extensive margin and this differs from the economy described above. This model assumes that labour supply is indivisible so that individuals are either working or not working. It also generates a large inter-temporal substitution effect for the individual because utility is linear in hours. We find that this improves the ability of the model to explain the cyclicality of productivity for EMEs. Moreover, it increases the relative volatility of hours because individuals are assigned to jobs randomly so there is a large labour supply elasticity. We conclude overall that most of our RBC models fail to explain labour market fluctuations in the business cycles of emerging countries, but that the model with investment adjustment cost improves the performance of the model in regard to the relative volatility of wages and hours, as well as the cyclicality of hours, compared to the standard RBC model for these countries.

Our paper is related to the work of Hansen and Wright (1992)[13] who present several extensions to the standard RBC model (such as nonseparable leisure and indivisible labour) and analyze the extent to which their models help to explain US business cycle facts (with a focus on productivity and hours). They find that these extensions improve the performance of the model at capturing some key labour market behaviour in the US. Our work is also in line, albeit indirectly, with that of Albonico, Kalyvitis, and Pappa (2012). They built a standard RBC model with temporary and permanent shocks, augmented with investment adjustment costs, in order to examine a productivity-hours puzzle in the RBC model. They find that the RBC model with investment adjustment costs could resolve the puzzle and generate negative co-movements between hours and productivity. In this study we show that introducing real frictions to the standard model brings the model closer to the data and helps us to explain better labour market fluctuations in the business cycles of EMEs compared to the standard RBC model.

Finally, we analyze the labour wedge, which measures the degree of inefficiency in the labour market, for business cycles in emerging countries and the US. In a frictionless RBC model setting, the marginal rate of substitution (MRS) and the marginal product of labour (MPL) should be equal, but in reality, the observation that these diverge when calibrated to the data, has led to a growing body of literature investigating the

[12] See also Rogerson (1988).

[13] See also Hansen (1985) and Christiano and Eichenbaum (1992). These papers modify standard RBC models by augmented indivisible labour and government consumption shocks to influence labour market dynamics in the US, respectively.

so-called labour wedge. Chari, Kehoe, and McGrattan (2007) have pointed to large cyclical changes in the relationship between the MRS between leisure and consumption and the MPL as an important feature of business cycles.[14] In this study we are also interested in the labour wedge because, firstly, it has relevance in explaining the business cycle, secondly, it provides information about labour market frictions during business cycles, thirdly, it has helped researchers to build a successful model of business cycle. We use the methodology proposed by Karabarbounis (2014), who studied the fluctuations in the labour wedge by decomposing this wedge in two: a gap between the MPL and real wage (firm's component) and a gap between the MRS and real wage (household's component). This methodology helps us to see which components are most responsible for the fluctuations in total labour wedge in these economies.

We find that most of the fluctuations in the total wedge come from the household, rather than the firm, component of the labour wedge in both EMEs and the USA. It means that researchers need to focus more on frictions coming from the household side of the model in order to better understand the labour market fluctuations of business cycles in these countries. We also investigate the cyclical properties of the firm and household components of the labour wedge, and of the total labour wedge, with output between 1970 and 2013 for these economies. We find that the total labour wedge (relative to output volatility) is more volatile in emerging countries (1.72) than in the US (0.95). Note that higher labour wedge would then represent a higher degree of labour market distortions. In particular, the relative volatility of the household component (2.09) and the firm component (1.24) of the labour wedge in the selected emerging countries is 2-3 times higher than the same components in the US. Last, the wedge in the US moves counter-cyclically to output;[15] however, for EMEs, we obtain heterogeneous results. For example, the total labour wedge moves cyclically to output in Costa Rica, and Peru, while it moves counter-cyclically in Colombia, Jamaica, Mexico, and Hungary. In the literature many factors have been highlighted as underpinning the cyclical behaviour of the labour wedge, which comes from not only by labour market frictions, but also through product market imperfections such as distortionary taxes and subsides, presence of rigidities and informal sector, unemployment benefits, and social security system. The heterogeneous cyclicality of the labour wedge shows that labour and product market distortions that affect the labour wedge are different among EMEs.

The remainder of this paper is organized as follows. In section 1.2, we present the data. Section 1.3 lays out our models. Section 1.4 discusses the values of parameters.

[14] See also Shimer (2009) and Ohanian and Raffo (2012), who have focused on the behaviour of the labour wedge at business cycle frequency.

[15] This result is consistent with Shimer (2009) and Ohanian and Raffo (2012)'s finding in the USA. They also have shown that the labour wedge is counter-cyclical for some European countries. The cyclical behaviour of the labour wedge still remains a puzzle in the literature.

Section 1.5 evaluates the performance of the models. Section 1.6 presents the labour wedge. Finally, section 1.7 provides concluding remarks.

1.2 Data

This section intends to provide a set of empirical facts to characterize the properties of the business cycles in emerging countries. Such a set may be useful to researchers that use RBC models to explain these economies as they are a crucial basis for the construction of such models. We first document the data sources, second the construction of variables, last the relevant business cycle facts in EMEs and the differences between these countries and the US. The countries, variables and sample lengths included in the analysis are listed in Appendix 1.B. We chose countries based on the availability of data; it is difficult to find quality data for certain variables and especially for data on hours worked and wages and there are a lot of missing observations. Hence, we had to reduce the time period for some countries and some variables. Still, we have sufficient annual data to provide an accurate picture of business cycles as can be seen the sample lengths in Appendix 1.B. However, for some countries, the results show that there is a nature of measurement error in the data as some of our results are not significant. It also contains some summary statistics for the data from the emerging countries and the US.

The data on GDP (total GDP, in millions of 1990 US dollars), hours worked, employment, and population (the population aged 15-64) are compiled from the Conference Board Total Economy Database (TED).[16,17] The data on wages, which are total compensation of employees, and consumption (household consumption expenditure data at constant (2005) prices in national currency, included non-profit institutions serving households) are collected from the United Nation Statistics Division, which publishes data on national accounts. The real wages data are calculated by deflating the total compensation of employees by the consumer price index. We collected the data for 15 emerging economies (Brazil, Bulgaria, Chile, Colombia, Costa Rica, the Czech Republic, Estonia, Hungary, Jamaica, Mexico, Peru, Slovenia, South Korea, Thailand, and Turkey) and for the US for the period 1970-2013.

We have used annual data instead of quarterly data since hours worked data is available only with annual frequency from emerging countries and all of the variables are converted to per capita terms. Thereby, our results might be slightly different from

[16]Time series data for these variables are available from the file "Output, Labour and Labour Productivity" on the TED website for most countries. Statistics are collected and constructed by national agencies.

[17]The GGDC Total Economy Database is the main source of estimates of hours worked per worker that are comparable across countries. These series are adjusted to reflect most sources of cross-country variation in hours worked, including the contracted length of the work week, statutory holidays, paid vacations, sick days and days lost due to strikes, and they are consistent with output. Rogerson (2006) and Ohanian and Raffo (2012) have also used this database in their study.

those in the relevant literature. As emphasized in Ravn and Uhlig (2001) and Ohanian and Raffo (2012)'s study, business cycle volatility in the annual data is lower than that in the quarterly data. Using annual data in the business cycles may not capture short-term dynamics, but it is still useful since it preserves medium term dynamics. We construct the variables as follows. *Employment per working age population (e)* is defined as the ratio of the level of employment (E) in the economy to the total working age population (P) of the country; *real GDP per capita (y)* is constructed using real GDP (Y) and the total working age population (P). Then *real wages per hour (w)* is constructed using the total real wages (W) over total hours worked (H) in the dataset. *Labour productivity (p)* is the ratio of real GDP (Y) to total hours worked (H) and, lastly, *consumption per capita (c)* is constructed by dividing household consumption expenditure (C) over total working age population (P):

$$e = \frac{E}{P}, \ y = \frac{Y}{P}, \tag{1.1}$$

$$w = \frac{W}{H}, \ p = \frac{Y}{H}, \ c = \frac{C}{P}.$$

We used two measures of hours worked as in Ohanian and Raffo (2012). First, we constructed *hours worked per employed person (he)*, using total hours worked (H) and employment (E). Second, we constructed *hours worked per working age population (hw)*, using total hours worked and working age population. *Hours worked per working age population (hw)* can be split into two parts as *the intensive margin* (hours worked per employed person) and *the extensive margin* (employed people divided by working age population). The reason for this split is to investigate whether most of the fluctuations in total hours worked come from the extensive margin or from the intensive margin in EMEs:

$$he = \frac{H}{E}, \tag{1.2}$$

$$hw = he * \frac{E}{P}.$$

To explain business cycle movements, any given data series is expressed in logs and de-trended using a Hodrick-Prescott (HP) filter (Hodrick and Prescott (1981)) with the standard smoothing parameter at 100 for annual data.[18] The reason why we use HP filter

[18]HP filter extracts a smooth trend from the variables since the variables analysed are non-stationary. See also Backus and Kehoe (1991), Backus, Kehoe, and Kydland (1992) and Rogerson and Shimer (2011), who de-trended their series using the HP filter with the smoothing parameter 100.

is that it tracks the data very closely as it is a standard approach towards de-trending in the modern macroeconomics literature.

For each variable j, Table 1.1 reports the standard deviation relative to the standard deviation of output σ_j/σ_y. Table 1.2 documents the autocorrelation of output $autocor(y)$ and the correlation with output $corr(j, y)$ for the business cycle frequencies of each emerging country and the US. We present *the extensive margin, the intensive margin and hours worked per working age population*, as well as *productivity and wages* to get familiar with the particularities of the business cycle in these economies. As mentioned previously, quantitative assessment is necessary to evaluate the effectiveness of RBC model in replicating actual data. Hence, it is important to ensure that the stylised facts are as accurate as possible. Note that we use *hours worked per working age population (hw)* when we compare the data and model moments in section 1.5, since we cannot separate employment from hours due to the fact that the whole population is employed in our models, except the model with indivisible labour.

Here, on average, are the second order moments of the labour market variables for these economies for the period of 1970-2013:

- The relative volatility of wages is about two times as volatile as the relative volatility of productivity for emerging countries. In terms of quantity, the intensive margin is clearly the least volatile of all.

- The relative volatility of wages (1.58) and productivity (0.81) are almost 2-3 times higher in EMEs than in the US, at 0.77 and 0.42, respectively. Notice that the relative volatility of hours worked (0.89) is higher than that of real wages (0.77) and productivity (0.42) in the US.

- In terms of quantity, the differences between the relative volatilities in emerging countries and the US are not large. The average value of the relative standard deviation of the extensive margin is 0.73 versus 0.27 for the intensive margin in the US, and 0.55 versus 0.26 in emerging economies, respectively. This finding reveals that the extensive margin contributes more to the variability of the total hours in these countries.[19]

- The co-movement of the labour market variables with output, on average, are all positively correlated for these countries, although at different levels of intensity. Procyclical behaviour corresponds most strongly with productivity (0.71) in EMEs, while total hours worked (0.90) and employment (0.88) correspond most strongly in the US. Compared to the US, the results show that extensive margin, total hours worked and real wages correlate less with output while productivity correlate more with output in emerging countries.

[19] It would have been worth analysing wages in the informal and formal sectors as well as employment in private and public sector. However, we could not ascertain which sector is most accountable for the variability of these variables in our sample countries, since we are not able to obtain data for these sectors.

Table 1.1: The Standard Deviations Relative to Standard Deviations with Output in Emerging Countries and the USA

Countries	$\frac{\sigma(e)}{\sigma(y)}$	$\frac{\sigma(he)}{\sigma(y)}$	$\frac{\sigma(hw)}{\sigma(y)}$	$\frac{\sigma(p)}{\sigma(y)}$	$\frac{\sigma(w)}{\sigma(y)}$
Brazil	0.76	0.04	0.76	1.07	3.10
Bulgaria	0.89	0.21	0.92	0.90	1.29
Chile	0.45	0.10	0.45	0.84	1.73
Colombia	0.77	0.43	0.91	0.71	1.24
Costa Rica	0.39	0.48	0.62	0.96	1.17
Czech Republic	0.36	0.33	0.51	0.83	0.94
Estonia	0.39	0.27	0.78	0.36	0.91
Hungary	0.75	0.39	0.86	0.73	1.28
Jamaica	0.74	0.38	1.01	0.63	1.19
Mexico	0.35	0.18	0.39	0.83	2.30
Peru	0.24	0.01	0.24	0.91	2.32
Slovenia	0.76	0.37	0.62	0.65	0.51
South Korea	0.59	0.37	0.67	0.71	1.76
Thailand	0.42	0.22	0.50	0.96	1.31
Turkey	0.51	0.21	0.50	1.09	2.68
Average	0.55	0.26	0.64	0.81	1.58
Median	0.51	0.37	0.62	0.83	1.29
USA	0.73	0.27	0.89	0.42	0.77

Note: This table presents the relative standard deviation of the *extensive margin (e)*, *intensive margin (he)*, *total hours worked (hw)*, *productivity (p)*, and *wages (w)* with the *output (y)* for the period 1970-2013. The series are logged first and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 100.

Table 1.2: Autocorrelation and Correlation with Output in Emerging Countries and the USA

Countries	$\rho(y)$	$\rho(e,y)$	$\rho(he,y)$	$\rho(hw,y)$	$\rho(p,y)$	$\rho(w,y)$
Brazil	0.57	0.27	0.14	0.28	0.73	0.68
Bulgaria	0.65	0.64	0.32	0.41	0.55	0.061
Chile	0.61	0.55	-0.01	0.54	0.89	0.67
Colombia	0.71	0.68	0.32	0.73	0.47	0.11
Costa Rica	0.62	0.65	-0.21	0.36	0.75	0.46
Czech Republic	0.58	0.38	-0.04	0.43	0.70	0.27
Estonia	0.73	0.66	0.83	0.92	0.65	0.30
Hungary	0.73	0.63	0.34	0.72	0.54	0.07
Jamaica	0.68	0.55	0.32	0.75	0.17	0.12
Mexico	0.58	0.76	-0.23	0.59	0.93	0.63
Peru	0.60	0.45	0.47	0.47	0.97	0.78
Slovenia	0.74	0.57	0.37	0.71	0.79	0.08
South Korea	0.47	0.75	0.06	0.70	0.74	0.54
Thailand	0.76	0.25	0.23	0.30	0.90	0.81
Turkey	0.48	0.12	-0.14	0.059	0.89	0.41
Average	0.63	0.52	0.18	0.56	0.71	0.39
Median	0.62	0.57	0.23	0.59	0.74	0.41
USA	0.55	0.88	0.61	0.90	0.47	0.54

Note: This table presents the autocorrelation of *output (y)*, correlation of the *extensive margin (e)*, *intensive margin (he)*, *total hours worked (hw)*, *productivity (p)*, and *wages (w)* with the *output (y)* for the period 1970-2013. The series are logged first and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 100.

- The correlation of intensive margin (0.61) with output in the USA is about three and half times higher than in the emerging countries (0.18). Lastly, output is somewhat more persistent in the EMEs, with an autocorrelation of 0.63, compared to the USA, at 0.55.

We now turn our attention to the country-level analysis. It is obvious that the properties of labour market fluctuations in many emerging countries differ from each other despite the similar picture emerges among some economies. Note that labour market institutions may vary among EMEs in terms of employment protection, firing and hiring costs, the unions, wage rigidity, informal sectors, social protection and unemployment benefits although they share some common features in their market. Naturally, these institutional discrepancies may produce different effects on the labour market variables.

- Bulgaria (0.89) shows the highest relative volatility of extensive margin among EMEs while Peru (0.24) is the least volatile. Furthermore, the relative volatility of extensive margin in Brazil, Columbia, Hungary, Jamaica and Slovenia are about as volatile as USA (0.73).

- Brazil, Costa Rica, Thailand and Turkey have the highest volatile productivity among all countries but they do not deviate very much from the average (0.81).

- The relative volatility of wages in Brazil (3.10), Peru (2.32), Mexico (2.30) and Turkey (2.68) are much higher than the average volatility of wages in emerging countries (1.58) while Slovenia shows the lowest wages volatility, at 0.51.

- Since the results show some extreme values for real wages in the country level analysis, we exclude these extreme values from our analysis. Then we found a lower volatility of wages, at 1.24 compared to the average. Moreover, we took the median of our sample and found that the effect of the outliers is smaller (1.30) compared to the average.[20]

- The co-movement of the labour market variables with output for these economies are positively correlated. However, Costa Rica, Mexico and Turkey are the only countries in our sample where the correlation of intensive margin with output is negative at -0.21, -0.23 and -0.14, respectively.

- Lastly, the correlation of wages and productivity is strongest with output in Peru at 0.78 and 0.97, respectively while Estonia shows the lowest correlation of productivity with output (0.36).

This section has described labour market facts that consist of endogenous variables that are the same as those in a simple RBC model and relate to EMEs and the US. The results confirm the fact that business cycles in emerging countries do not follow the same patterns as in US albeit some similar patterns emerge in country-level analysis.

[20] The median is not impacted by the extreme values. Note that, in section 1.5, we also compare our model moments with those for which we dropped extreme observations and median. Then, we look at the performance of our models in term of these values.

The striking aspect of these results is that the labour markets in EMEs adjust more through prices while quantities are subdued. In the emerging market business cycle literature, Neumeyer and Perri (2005), Boz, Durdu, and Li (2009a) and Li (2011) document statistics on labour market variables using semi-annualized, quarterly and both annual and quarterly data, respectively. They find that the quantity variables are less variable and less correlated with output in EMEs compared to the US. Moreover, they find that the volatility of wages relative to output in EMEs is almost twice as high as that in the developed economies, and real wages are positively correlated with output. Our findings on these variables are roughly in line with those studies. In the next section, we will examine how well the standard RBC model can fit these facts in emerging countries. We will also look at the performance of an RBC model augmented with some real frictions.

1.3 The Model

The benchmark model we present here, motivated by the findings in the previous section, is a canonical RBC model designed to assess fluctuations in the hours worked, wages, productivity and output of business cycles in EMEs including transitory TFP shock and a permanent labour-augmenting productivity shock as in Aguiar and Gopinath (2007). These shocks have been widely studied in the literature[21] which find that the business cycles in emerging countries are mainly driven by shocks to trend growth rather than transitory fluctuations around a stable trend. They interpret the shocks to the trend growth as dramatic changes in institutions and policy in emerging countries. Then we look at several variants of the standard RBC model in the literature.

The model consists of households and firms. The households consume, invest in capital and provide labour and capital for the firms. The firms rent labour and capital from the households.[22]

1.3.1 The Standard Real Business Cycle (RBC) Model

1.3.1.1 The Household's Problem

The model economy is populated by a continuum of identical consumers. The preferences of households are defined by consumption, C_t, and hours worked, H_t, and are described by the utility function:

$$E_0 \sum_{i=0}^{\infty} \beta^t \ u(C_t, H_t), \tag{1.3}$$

[21] See also Chang and Fernández (2010) and Garcia-Cicco, Pancrazi, and Uribe (2010).

[22] The equilibrium of the models is derived in Appendix 1.A.

where preferences are non-separable:[23]

$$U(C_t, H_t) = \frac{\left(C_t^{\psi}(1-H_t)^{1-\psi}\right)^{1-\sigma} - 1}{1-\sigma}. \tag{1.4}$$

$E\,(.)$ denotes the expectation operator, conditional on information available at time t, β is the discount factor between zero and one. As a baseline we use a non-separable utility function which implies that the preferences are non-separable in terms of consumption and hours. $U\,(.)$ represents a period utility function. The parameter σ is the inverse of the inter-temporal elasticity of substitution for consumption. That is the inter-temporal elasticity of substitution for consumption is given by $\frac{1}{\sigma}$. ψ determines the inverse of the Frisch elasticity of labour supply. This utility function eliminates the wealth effect on leisure; hence, the labour supply depends on wages. Also, this function is compatible with balanced growth and stationary hours, irrespective of choice for σ, which implies that households do not increase their work hours in response to permanent productivity growth.

We have further simulated the model with the separable utility function. In contrast to the non-separable utility function, this implies an effect of wealth on leisure.[24] In order for the model to be compatible with a balanced growth path we have to restrict σ equal to 1, which implies that the utility function is logarithmic for consumption whose marginal relation of substitution between consumption and leisure is linear in consumption. Hence, hours are constant in the model while the other variables grow over time according to the permanent stochastic shock. Household maximizes the following lifetime utility function:

$$U(C_t, H_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \chi\,\frac{H_t^{1+\psi}}{1+\psi}\,. \tag{1.5}$$

where χ specifies the preference weight of hours in utility. The Frisch elasticity for labour supply is simply $\frac{1}{\psi}$. The reason we consider both these preferences is to determine whether or not our results are sensitive to differences in preferences used in the analysis. In section 1.4, we will report the results for both preference specifications.

A household is assumed to own capital, K_t, which accumulates according to the following law of motion:

[23] See Hotz, Kydland, and Sedlacek (1988)'s work, who has examined the importance of non-separable preference structures in the model.

[24] The labour supply is not independent of consumption as in the non-separable case, so that households substitute consumption for leisure. Also, when we look at the first-order condition of hours in equation 1.A.4 in Appendix, we clearly see that there is a negative relationship between hours worked and consumption.

$$K_{t+1} = (1-\delta)\, K_t + I_t, \tag{1.6}$$

where I_t denotes investment, and δ is the depreciation rate of capital.

The households are subject to the following inter-temporal budget constraints:

$$C_t + I_t = W_t H_t + R_t K_t, \tag{1.7}$$

where W_t denotes the household's real wage rate, and R_t represents the rental rate of capital. Consumers choose to maximize utility subject to capital accumulation and their budget constraints:

$$C_t + K_{t+1} = W_t H_t + R_t K_t + (1-\delta)\, K_t. \tag{1.8}$$

1.3.1.2 The Firm's Problem

Firms have access to the following Cobb-Douglas production function, which uses capital K_t and labour H_t from households. Production technology takes the form

$$Y_t = e^{z_t} K_t^{1-\alpha} (H_t \Gamma_t)^{\alpha}, \tag{1.9}$$

where Y_t is output and $\alpha \, \epsilon \, (0,1)$ is the labour share in output. The parameters z_t and Γ_t are stochastic productivity processes which are characterized by different stochastic properties. Specifically the temporary shock, z_t, to total factor productivity is stationary and follows the $AR(1)$ process:

$$z_t = \rho_z z_{t-1} + \varepsilon_t^z, \tag{1.10}$$

with $|\rho_z| < 1$ as the persistence of the transitory productivity shock and ε_t^z representing an independent and identical distribution (iid) drawn from a normal distribution with a zero mean and standard deviation σ_z.

The permanent labour-augmenting productivity shock, Γ_t, is non-stationary and represents the cumulative product of "growth shocks"; it is given by

$$\Gamma_t = g_t \Gamma_{t-1} = \prod_{s=0}^{t} g_s,$$

$$\ln(g_t) = (1-\rho_g)log(\mu_g) + \rho_g ln(g_{t-1}) + \varepsilon_t^g.$$

where the parameter g_t represents the rate of growth of the permanent technology shock. $|\rho_g| < 1$ represents the persistence parameter of the process g_t, and ε_t^g represents iid drawn from a normal distribution with a zero mean and standard deviation σ_g. μ_g represents the long run average growth rate of productivity. Notice that shocks to g_t permanently affect labour productivity, Γ_t.

1.3.1.3 Labour and Capital Demand

If we assume that the factor market is characterized by perfect competition then the real rental rate on capital R_t^K and real wage W_t is given by

$$R_t^K = e^{z_t}\ (1-\alpha)\ (\frac{K_t}{H_t})^{-\alpha}\Gamma_t^{\alpha}, \tag{1.11}$$

$$W_t = e^{z_t}\,\alpha\,(\frac{K_t}{H_t})^{1-\alpha}\,\Gamma_t^{\alpha}.$$

1.3.1.4 Equilibrium Conditions in Stationary Form

Since the model exhibits balanced growth all of the non-stationary variables have to be de-trended. Hence, we normalize all of the variables except H_t with trend shock Γ_t to induce stationarity. The de-trended versions of the respective variables are defined as follows:

$$\hat{C}_t \equiv \frac{C_t}{\Gamma_t}, \hat{Y}_t \equiv \frac{Y_t}{\Gamma_t}, \hat{I}_t \equiv \frac{I_t}{\Gamma_t},$$

$$\hat{K}_{t+1} \equiv \frac{K_{t+1}}{\Gamma_t}, \hat{W}_t \equiv \frac{W_t}{\Gamma_t}.$$

We have the following equilibrium conditions which characterized this economy:

Cobb-Douglas production function:

$$\hat{Y}_t = e^{z_t}\hat{K}_{t-1}^{1-\alpha}H_t^{\alpha}g_t^{-1}, \tag{1.12}$$

Labour demand:

$$\hat{W}_t = \alpha\hat{Y}_t/H_t,$$

Demand for capital:

$$R_t^K = (1-\alpha)\hat{Y}_t/\hat{K}_{t-1}g_t^{-1},$$

Labour supply :

$$(1-\psi)\hat{C}_t = \psi(1-H_t)\hat{W}_t,$$

Euler for capital:

$$\hat{C}_t^{\psi(1-\sigma)-1}(1-H_t)^{(1-\psi)(1-\sigma)} = \beta g_{t+1}^{\psi(1-\sigma)-1}$$

$$\hat{C}_{t+1}^{\psi(1-\sigma)-1}(1-H_{t+1})^{(1-\psi)(1-\sigma)}(1+R_{t+1}-\delta),$$

Law of motion for capital:

$$\hat{K}_t = (1-\delta)\hat{K}_{t-1}g_t^{-1} + \hat{I}_t,$$

Aggregate resource constraints:

$$\hat{C}_t + \hat{K}_t = \hat{Y}_t + (1-\delta)\hat{K}_{t-1}\ g_t^{-1},$$

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t.$$

1.3.2 Extensions

It is well known in the early moment matching exercises where the standard RBC model are incapable of replicating the second moments of labour market dynamics.[25] Hence, different extensions to and modifications of the RBC model have been proposed by many researchers. Following the literature we have built an augmented RBC model with capacity utilization, investment adjustment cost and indivisible labour with temporary and permanent productivity shocks to explain labour market facts observed in the data. We analysed these models using a unified framework with common functional forms and parameter values. Thus, we could easily compare how they affect the models' ability to explain the data facts. The idea using these extensions is to show how far these models can take us in explaining labour market fluctuations of EMEs.

[25] For details, see Hansen and Wright (1992) and Christiano and Eichenbaum (1992).

1.3.2.1 The RBC model with Capacity Utilization

In the literature many papers have argued that standard RBC models fail to explain certain features of the data because it lacks a propagation mechanism for productivity shocks as it only considers these shocks as main source of aggregate fluctuations.[26] The basic idea of using capacity utilization is that it allows capital to vary in response to productivity shocks in business cycle fluctuations by intensifying the capital while the capital enters for a predetermined period in the model. Hence, this mechanism substantially improves the ability of the model to account for the features of the data.

Greenwood, Hercowitz, and Huffman (1988a) suggest that a variable capacity utilization rate may be important for understanding of business cycles since it provides a channel through which shocks via their impact on capacity utilization can affect labour productivity and hence equilibrium employment. Moreover, Burnside and Eichenbaum (1994) study the role of capacity utilization in propagating shocks over the business cycle. They find that it magnifies and propagates the impact of the shock since it provides an additional margin to adjust the level of output. Unlike Cogley and Nason (1995), they find that the model can simultaneously account for the univariate time series properties of the growth rate of output when it includes capacity utilization. Also, Boileau and Normandin (1999) study the role of capacity utilization in business cycle fluctuations. They find that their model economy tracks well the role of capacity utilization in business cycle fluctuations. Motivated by the findings in the literature, we hence examine the extent to which capacity utilization helps the RBC model match the labour market facts in EMEs.

In this model, the law of motion for capital becomes

$$K_{t+1} = (1 - \delta\ X_t^{\Omega})K_t + I_t, \tag{1.13}$$

X_t represents the capacity utilization rate, and the parameter Ω determines the intensity of capacity utilization. The term $\delta\ X_t^{\Omega}$ shows the capital depreciation rate, which depends on capital utilization, where δ is increasing and convex in X_t and $\Omega > 1$.

The production function depends on hours, the amount of capital and utilization as follows:

$$Y_t = e^{z_t}(K_t X_t)^{1-\alpha}(H_t \Gamma_t)^{\alpha}, \tag{1.14}$$

The term $K_t X_t$ represents capital services which depend on the production of utilization and the amount of physical capital. To understand the role of capacity utilization in amplifying and propagating business cycles in this model, it is useful to derive a

[26] See Cogley and Nason (1995) who highlight the weak propagation mechanism in standard RBC model by focusing on the autocorrelation function of the growth rate of output.

reduced-form aggregate production function evaluated at the optimal rate of capacity utilization. The first order condition with respect to capacity utilization X_t is

$$(1-\alpha)\frac{Y_t}{X_t} = \Omega\delta X_t^{\Omega-1} K_t. \tag{1.15}$$

Equation 1.15 shows that marginal output of an increase in the capacity utilization rate equals to the marginal change in capital depreciation rate due to the intensified usage of existing capital stock.

1.3.2.2 The RBC Model with Investment Adjustment Costs

We also explore the role of investment adjustment costs in a standard RBC model. The reason why we are interested in these costs is that the standard RBC model causes a high volatility of investment since firms adjust their capital stock to the optimal level instantaneously. However, the incorporation of investment adjustment costs into the RBC model prevents investment quickly responding to changes in economic conditions.

Furthermore, recent studies consider investment adjustment cost as a key mechanism that significantly improves the quantitative performance of the models along a number of dimensions. Burnside, Eichenbaum, and Fisher (2004) find that these costs may explain the effects of a fiscal shock on hours and wages. Moreover, Albonico, Kalyvitis, and Pappa (2012)[27] find that the RBC model with investment adjustment costs could resolve the productivity-hours puzzle and generate negative co-movements between hours and productivity. They further explain that these costs mitigate the impact effect of a productivity shock on the capital stock, hence hours increases relatively less on equilibrium.

We have the following properties as in Christiano, Eichenbaum, and Evans (2005) for the functional form of the investment adjustment costs. They show that adjustment costs on investment can generate a hump-shaped response in investment, consumption and employment consistent with the estimated response to a monetary policy shock. In this model, households face investment adjustment costs based on current and lagged investments. Thus, the law of motion for capital, with adjustment costs for investments, is given by

$$K_{t+1} = (1 - \frac{\phi}{2}(\frac{I_t}{I_{t-1}} - 1)^2)I_t + (1-\delta)K_t, \tag{1.16}$$

The term $\frac{\phi}{2}(\frac{I_t}{I_{t-1}} - 1)^2$ with $\phi > 0$ captures the adjustment costs on investment I_t. It implies that there is a cost associated with changing the level of investment, that this cost is zero at steady state and that this cost is increasing in the change in investment.

The Lagrangian multiplier for the model with investment adjustment costs is as follows:

[27] See also Khan and Groth (2007)'s work.

$$q_t = \frac{\theta_t}{\lambda_t}, \tag{1.17}$$

We define Tobin's q_t as the shadow value of having an extra unit of capital, θ_t, and marginal utility of consumption, λ_t. If there are no adjustment costs, q_t equal to 1, that is the Tobin's marginal q_t should be equal to the replacement cost of installed capital in units of the final good.

We do not present all of the stationarized equations since some of them are the same as in the basic RBC model. We have the following equilibrium conditions that characterize this economy

Euler for capital:

$$\hat{q}_t = \beta \frac{\hat{\lambda}_{t+1}}{\hat{\lambda}_t} g_{t+1}^{-1}((1-\delta)q_{t+1} + R_{t+1}), \tag{1.18}$$

Euler for investment:

$$1 = \hat{q}_t(1 - \frac{\phi}{2}(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_t - 1)^2 - \phi(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_t - 1)\frac{\hat{I}_t}{\hat{I}_{t-1}}g_t) + \beta\hat{q}_{t+1} \tag{1.19}$$

$$\frac{\hat{\lambda}_{t+1}}{\hat{\lambda}_t} g_{t+1}^{-1} \phi(\frac{\hat{I}_{t+1}}{\hat{I}_t} g_{t+1} - 1), (\frac{\hat{I}_{t+1}}{\hat{I}_t} g_{t+1})^2,$$

Law of motion for capital:

$$\hat{K}_t = (1 - \frac{\phi}{2}(\frac{\hat{I}_t}{\hat{I}_{t-1}}g_t - 1)^2)\hat{I}_t + (1-\delta)\hat{K}_{t-1}g_t^{-1}. \tag{1.20}$$

where q_t is the shadow price of capital in terms of consumption. Equation 1.20 is the present discounted value of having an additional unit of capital, measured in terms of its future value and the rental rate.

1.3.2.3 The RBC Model with Indivisible Labour

One failure of the standard RBC model is that it fails to generate sufficient volatility in hours worked. It also models hours which are all fluctuations in hours worked solely come from the intensive margin as opposed to the extensive margin, in particular, we can see hours as employment only where employment is perfectly divisible. However, Hansen (1985) emphasizes that fluctuations in hours worked in the real world come from the changes in both the extensive and intensive margins. His findings about the US, which revealed that most of the fluctuations in hours are mainly due to variations in the extensive margin (i.e., the employment rate), support the modelling of the RBC model with indivisible labour.

In this study, the adoption of the indivisible model is very close to the EMEs experience. As reported in previous sections, fluctuations of the extensive margin are mostly responsible for fluctuations in the total hours worked in these economies rather than fluctuations in the intensive margin. In this model, utility is linear in h_t, and the inter-temporal elasticity of substitution is infinite for households. Thereby, labour supply varies to a greater extent inter-temporally in this economy. The utility function is given by

$$U(c_t, h_t) = ln(c_t) + Aln(1 - h_t), \tag{1.21}$$

A describes the weight on leisure in the utility function. Households uniformly have the same probability of working as they are identical in terms of skills and productivity. Thus,

$$U(c_t, h_t) = ln(c_t) + A[\pi_t ln(1 - h_0) + (1 - \pi_t)ln(1)],$$

$$U(c_t, h_t) = ln(c_t) + A\pi_t ln(1 - h_0),$$

where h_t represents hours worked per capita. Indivisible labour is modelled by restricting the consumption possibilities set so that households work h_0 with a probability of π_t and the rest work zero (i.e., there is an employment lottery). As was also pointed out by Rogerson (1988), in the equilibrium of this model, individuals randomly assign to employment or unemployment in each period with consumption insurance against the possibility of unemployment. Hence, this model can produce fluctuations in employment over the business cycle. This is given by

$$h_t = \pi_t h_0, \tag{1.22}$$

Preferences can be written as

$$U = ln(c_t) + A\frac{ln(1 - h_0)}{h_0}h_t, \tag{1.23}$$

$$B = -A\frac{ln(1 - h_0)}{h_0}, \tag{1.24}$$

B represents the dis-utility parameter of composite labour. Therefore, we can write it within the period utility function as

$$U(c_t, h_t) = ln(c_t) - Bh_t. \tag{1.25}$$

1.4 Calibration

Table 1.3 shows the list of parameters we parametrize in order for the model to match data. It is important to have a good understanding of rationale behind the selection of the particular parameter values in order to properly evaluate the fit of the model for EMEs. In this study, the parameter values are generally picked from the existing literature due to lack of quality data in estimating these values governing stochastic productivity processes, preferences, production and adjustment costs in these countries. Therefore, we have relied on highly conventional parameters widely used in the DSGE models of annual frequency for the US. More specifically, the model is calibrated to match annual frequency and these values are fit for emerging countries.

The labour share α is calibrated to match the capital share data. We hence set α in production to 0.68, which is a standard value for the long run labour share income so that the value of capital share is set to $1/3$ to match the average fraction of total income going to capital in EMEs. The discount factor β is calibrated to match the steady-state capital-output ratio in the capital Euler equation to that in data. The value of β used in literature ranges from 0.92 to 0.99 for annual frequency for emerging countries. We set this value to 0.95, in order to imply a steady-state real interest rate at about 5% per year, which is a value compatible with the observed interest rate face by emerging countries.[28]

We set the inverse of the Frisch elasticity of the labour supply ψ of the utility function to 0.33 so that it matches the steady state labour input level in the labour first order condition to that in data which is commonly used in the RBC literature. The value of the depreciation rate δ ranges from 0.03 to 0.12 per year for EMEs in the literature. We have used a 7% annual depreciation rate to match the capital law of motion as it falls almost in the middle of that range.[29] Since we have a permanent shock in the model, we set the coefficient of relative risk aversion σ to 1 in the case of the separable utility function in order to have a balanced growth path. However, we set the inverse of the inter-temporal elasticity of substitution to 2 which ranges from 1 to 2 in the case of the non-separable utility function in the standard business cycle literature.[30] We set the

[28]However, Garcia-Cicco, Pancrazi, and Uribe (2010) set the parameter β to 0.92, which implies a relatively high average real interest rate of about 8.5 percent annually. They also explained that this value is empirically plausible for emerging market like Argentina.

[29]Li (2011) have set the depreciation rate to 3% while Garcia-Cicco, Pancrazi, and Uribe (2010) have set this value to 12% for annual frequency.

[30]As in Li (2011). She calculates the σ based on data from Mexico.

Table 1.3: Parameter Values in Models

Parameters	Definition	Value
β	The Discount factor	0.95
ψ	The inverse of the Frisch elas. of labour supply	0.33
α	The labour share of output	0.68
σ	The inter-temporal elasticity of subs. for consumption	2
δ	The depreciation rate of capital	0.07
μ_g	The productivity's mean growth rate	log(1.0066)
ρ_z	The persistence of transitory shocks	0.6
ρ_g	The persistence of growth shock	0.01
ϕ	The adjustment cost on investment	4

investment adjustment cost parameter, ϕ, to 4 following Albonico, Kalyvitis, and Pappa (2012).[31]

We used the five parameters to define the stochastic processes of the productivity shocks, g, ρ_z, ρ_g, ϵ_g, ϵ_z. The persistence value of the temporary shock, ρ_z, is set to 0.6 and the persistence of the permanent shock, ρ_g, is set to 0.01.[32] Then we set the long-run productivity growth, μ_g, to log (1.0066) as in Aguiar and Gopinath (2007), who calibrate this value based on the average growth factor of the Mexican economy in their data. The standard deviation of the temporary shock, ϵ_z, and the permanent shock, ϵ_g, are normalized to 1%, which is compatible with the commonly used values in literature. In the next section, we first present the results based on our baseline parameter values in Table 1.4. Then we discuss the sensitivity of our results, in light of the different parameter values used in other studies.

1.5 Results

The aim of this section is to show how the RBC models fit the features of the data for emerging countries and the US. The model we built generates data de-trended by the stochastic trend therefore, we have to obtain the level by adding back the permanent shock. We then log and de-trend this data as well using HP filter so that we can compare properly the data and the model moments. In Table 1.4, we selected the following

[31] They use the values between 0 and 20 for the investment adjustment cost.

[32] The persistence of the permanent shock, ρ_g is taken from Aguiar and Gopinath (2007). They set the persistence value of the temporary shock, ρ_z as 0.95. The reason why we choose the lower value for ρ_z is that we use annual data but they use quarterly data. The persistence of the temporary shocks with annual data should be lower than quarterly data.

moments to be generated by our artificial economy as in data: the relative standard deviation of output with hours worked, wages and productivity, the autocorrelation of output and the correlation of these variables with the output. Note that the marginal and average productivity of labour are proportional to each other; therefore, the moments of the model for productivity and wages are the same.

TABLE 1.4: Business Cycle Moments

	Data	USA	Model1	Model2	Model3	Model4	Model5	Model6	Model7
$\sigma(h)/\ \sigma(y)$	0.64	0.89	0.54	0.51	0.65	0.60	0.63	0.63	0.72
$\sigma(w)/\ \sigma(y)$	1.58	0.77	0.60	0.64	0.45	0.50	1.02	1.03	0.51
$\sigma(p)/\ \sigma(y)$	0.81	0.42	0.60	0.64	0.45	0.50	1.02	1.03	0.51
$\rho(y)$	0.63	0.55	0.36	0.37	0.35	0.36	0.32	0.32	0.36
$\rho(y,h)$	0.56	0.90	0.86	0.83	0.94	0.94	0.57	0.56	0.87
$\rho(y,w)$	0.39	0.54	0.89	0.90	0.87	0.90	0.99	1.00	0.73
$\rho(y,p)$	0.71	0.47	0.89	0.90	0.87	0.90	0.99	1.00	0.73

Note: σ represents relative volatility with the output and ρ represents the correlation with output. The terms h, y, w, and p stand for hours, output, wages and productivity, respectively. The first column of the table reports the results for the data moments on average for emerging countries and the second column presents the moments of US data for business cycle frequencies between 1970-2013. In the following columns, Model 1, Model 3 and Model 5 show the moments of our benchmark model, the model augmented capacity utilization and investment adjustment costs with the non-separable utility function, respectively. Model 2, Model 4 and Model 6 represent the results of these models associated with the separable utility function. Lastly, Model 7 shows the performance of the RBC model with indivisible labour.

The results for the standard RBC model are presented in column 3 and corresponds to the case in which we introduce only permanent and temporary productivity shocks. It can be seen that this model does a fairly good job of matching the relative volatility of hours, but it does not generate enough volatility of productivity and especially wages for these economies since the volatility of wages relative to output is much higher in the data than in the model. In addition, the model produces a positive and significant correlation for hours worked, wages and productivity with output, which are at odds with the data for EMEs. Moreover, this model replicates satisfactorily the correlation between hours and output for the US but it fails to capture the rest of the moments although the results are slightly better for this country compared to emerging economies.

The standard RBC model fails to account for many features of the data as it does not embody quantitatively important propagation mechanism. Model 3 introduces the capacity utilization in propagating shocks over the business cycle to the standard RBC model. In this model, we assume that the production function depends on labour, the amount of capital available and its utilization so capacity utilization alters the equilibrium production function as it amplifies the shocks. If capacity utilization does not vary much, it may be possible to increase the impact of shocks on hours worked and hence decrease labour productivity and real wages. As intuition would suggest we see that this model increases the relative volatility of hours worked from 0.54 to 0.65 so that it now matches perfectly in explaining hours volatility for emerging countries. In addition, capacity utilization decreases significantly the abilities of the model to replicate the relative volatility of wages and productivity for these economies, compared to the standard RBC model. The model also generates excessive contemporaneous correlation between hours and output as it fails to replicate the correlation between all labour market variables and output for these countries. Moreover, this model has a much better representation of the relative volatility of productivity for the US compared to the standard RBC model. We see that this modification is not sufficient to bring the model more in line with EMEs data.

Table 1.4 also presents the results of extending the standard model to include the investment adjustment costs. This mechanism into the RBC model prevents investment quickly responding to shocks as it mitigates the effect of shocks on capital stock. Therefore, hours worked fluctuate much more less than wages and productivity in this model compared to the standard model. This suggests that capital stock could not adjust instantly and therefore, neither could hours. The intuition behind this might be that the negative impact of adjustment costs on hours worked is amplified by the wealth effect in preferences as households increase their consumption and decrease their labour supply. It would seem that the model with investment adjustment costs does a slightly better job than the other models, especially for the correlation between hours and output for emerging economies as well as it improves significantly the abilities of the model to replicate the volatility of wages for these economies as it is still disappointing even though it increases the relative volatility of wages almost twice as much as the other models. Moreover, this model increases the relative volatility of productivity compared to the model with capacity utilization but it is still insufficient to match this fact.

Finally, Model 7 introduces the indivisible labour to the standard RBC model. In this model individuals are assigned to jobs randomly so this model generates a large inter-temporal substitution effect for the individuals. Hence, it raises the hours worked volatility and decreases the cyclicality of wages and then productivity for the same shocks, unlike the other models. In Table 1.4, it can be seen that it increases fairly the relative volatility of hours (0.72) but it still replicates this data fact for emerging countries. This model also decreases the correlation of wages and productivity with output, as the model with indivisible labour is a much better representation of the correlation between productivity and output for these economies compared to the previous models.

Figure 1.1: Contemporaneous, Lead and Lag Correlation Coefficients Between Labour Market Variables and Output

Output is persistent with an autocorrelation of around 0.35 in the models as this is driven mainly by the persistence coefficients of the shocks. Figure 1.1 shows the average contemporaneous, lead and lag correlation coefficients between the labour market variables from period $t-4$ to $t+4$ and the output for the actual data and the simulated data. We see that the cross-correlation of these variables exhibits a hump-like shape for both data but the model does not generate fairly the results as in the actual data. In particular, we figure out that hours worked, productivity and wages are pro-cylical in the actual data as well as in the simulated data although the model seems to reproduce a higher contemporaneous correlation, leading the cycle by four quarters in both. In addition, the model produces higher correlation between hours and output until one lag but lower correlation for productivity and wages until four lags compared to the real data.

For sensitivity, we set the value of ρ_z in our benchmark model as in Aguiar and Gopinath (2007) as 0.95. The results show that the volatility of hours (0.30) significantly decreases but the volatility of wages (0.80) increases so the persistence of temporary shocks matters how labour supply and demand react.[33] Furthermore, we shut down the interaction between temporary shock and permanent shock in our baseline model, it means that ϵ_z or ϵ_g is equal to 0. The reason we do this is that if technology shocks affect wages through the marginal product of labour relationship, then this affects hours through labour supply, leading to labour market dynamics that will be different if the shocks are only temporary or if they are only growth shocks. When we shut down the temporary shock we find that there is a significant decrease in the volatility of hours worked (0.20). It under-predicts the performance of the model in terms of the matching hours worked volatility but improves the performance of the model in terms of productivity volatility (0.96) and wages volatility (0.96). It also raises the persistent of the output to 0.40. When we shut down the permanent shock, the model significantly under-predicts the volatility of wages (0.44) and there are not much significant changes in terms of the correlation of the variables compared to the standard RBC model.

We also check the results by altering the values of σ, ϕ and ψ while holding the other parameters constant. In the non-separable utility function the value of ψ is important because the steady state of hours has to be 1/3 but we can assign different values to σ. Thus, we set the value of σ to 0.99. Additionally, in the case with the separable utility function the value of σ has to be 1 for balanced growth but we could assign different values to ψ. Lastly, we set the adjustment cost to 2 as in line with Albonico, Kalyvitis, and Pappa (2012)'s study. We discovered that our results are slightly different but it does not change the performance of our models to explain labour market facts for emerging countries. In addition, Table 1.4 shows that our results are not sensitive to differences in preferences used in the analysis.

Overall, as can be seen, these models are less than ideal for explaining the variability of wages in these countries but they do a fairly good job of matching the variability of hours. Moreover, the model with investment adjustment costs does a slightly better job than the other models, especially for the correlation between hours and output as well as the relative volatility of hours and wages, but it still does not perform so well in regard to the volatility of wages, even though it increases the relative volatility of wages almost twice as much as the other models. In addition, we compare our models' moments with those for which we drop the extreme observations and calculate the medians. Then, we look at the performance of our models in terms of these values and find that our models do a better job of explaining only the high volatility of wages in these economies.

[33] When we change the persistence of permanent shocks (as 0.1), we almost obtain the similar results with our benchmark model.

1.6 The Labour Wedge

In this section we analyse the labour wedge which measures the degree of inefficiency in the labour market for business cycles in EMEs and the US. We look at it through the lens of a standard RBC model on the labour market. From the set-up of the model we know that the household's first order condition which measures the marginal rate of substitution (MRS), is equal to wages (w) and the firm's first order condition which measures the marginal product of labour (MPL) is also equal to wages (w). Thus, the optimal choice of hours is determined in equilibrium such that the MRS and MPL are equal to each other. However, this condition is violated empirically, and that the labour wedge, defined as a gap between these two objects, is characterized by large cyclical variations.

In the recent years, many researchers have shown great interest in the behaviour of labour wedge at business cycle frequency. Chari, Kehoe, and McGrattan (2007) have pointed out that large cyclical changes in the relationship between the MRS and MPL as an important feature of business cycles. They find that it accounts for 60% of output fluctuations in the US, putting it at the center of their business cycle accounting research.[34] Moreover, Lama (2011) finds that labour wedge is important in accounting for output drops in Argentina, Brazil, Chile, Colombia, Mexico and Peru as Simonovska and Soderling (2015) shows that the labour wedge is one of the most important wedges responsible for business cycle changes in Chile. The purpose of looking at labour wedge in this paper is to give insight into the labour market frictions or distortions to account for the business cycles in EMEs and provides a useful guide for researchers about where to introduce frictions into their models.

Given the relevance of the topic we are interested in exploring whether the fluctuations in the labour wedge come mostly from the household component or the firm component of the labour wedge in the emerging countries and the US. Such analysis is important to understand whether frictions at the firm level or the household level are relatively more important in these economies for building a successful model of the business cycle. For this analysis, using the methodology proposed by Karabarbounis (2014),[35] we decompose the labour wedge into a gap between the MPL and the real wage (the firm component of the labour wedge) and into a gap between the real wage and the MRS (the household component of the labour wedge):

$$exp(-\tau_t^f)MPL_t = w_t, \tag{1.26}$$

$$exp(\tau_t^h)MRS_t = w_t,$$

[34] Also, Shimer (2009) and Ohanian and Raffo (2012) focus on the behaviour of the labour wedge at business cycle frequency.

[35] We follow this paper setting discretionary time available work and leisure equal to 92 hours per week per person.

where τ_t^f denotes the firm component of the labour wedge, and τ_t^h denotes the household component. The total labour wedge, τ_t is defined as the gap between the MPL and the MRS:

$$\tau_t = log(MPL_t) - log(MRS_t) = \tau_t^f + \tau_t^h. \tag{1.27}$$

Table 1.5 shows the cyclical properties of the firm and household components of the labour wedge and of the total labour wedge with output between 1970 and 2013 for these economies. We find that total labour wedge (relative to output volatility) is more volatile in emerging countries (1.72) than in the US (0.95). These results show that the degree of labour market distortions is higher in EMEs compared to the US. In particular the relative volatility of the household component (2.09) and the firm component (1.24) of the labour wedge in emerging countries is 2-3 times higher than the same components in the US.

We also found that the wedge in the US moves counter-cyclically to output; however, for emerging countries we obtain heterogeneous results. For example: the total labour wedge moves cyclically to output in Costa Rica and Peru while it moves counter-cyclically in Colombia, Jamaica, Mexico, and Hungary. In the literature many factors have been highlighted behind the cyclical behaviour of the labour wedge which comes from not only by labour market frictions, but also by product market imperfections such as distortionary taxes and subsides, presence of rigidities and informal sector, unemployment benefits, and social security system. The heterogeneous cyclicality of the labour wedge shows that labour and product market distortions that affect labour wedge are different among EMEs. When we compare our results with those of Karabarbounis (2014)'s work for the US, we find our results to be slightly different, especially for the correlation between the firm component of the labour wedge and output. We obtain a negative value for this, while he finds a positive value. This could be because he uses quarterly data and adjusted wages for taxes but we use annual data and not tax-adjusted real wages.

Moreover, Figure 1.2 shows that the fluctuations in the labour wedge predominantly reflect fluctuations in the gap between the real wage and the marginal rate of substitution for emerging economies and for the US. This implies that there is a strong relationship between the household component of the labour wedge and the overall labour wedge in both countries since the household component co-moves very closely with the total wedge. The standard business cycle model does not specify the underlying source of the labour wedge but we can conclude that researchers need to focus on frictions coming from the household component of wedge to better analyse the labour market fluctuations of business cycles in these economies as the model does badly on explaining hours and wages. This study could be a useful source to motivate future research on the topic for these economies. Lastly, we have figured out that our results are insensitive to the choice of preferences in our analysis.

Table 1.5: The Cyclical Properties of The Firm and Household Components of the Labour Wedge in Emerging Countries and USA

Countries	$\frac{\sigma(\tau^f)}{\sigma(y)}$	$\frac{\sigma(\tau^h)}{\sigma(y)}$	$\frac{\sigma(\tau^T)}{\sigma(y)}$	$\rho(y,\tau^f)$	$\rho(y,\tau^h)$	$\rho(y,\tau^T)$
Brazil	2.10	2.21	0.93	-0.50	0.45	-0.05
Bulgaria	1.17	2.22	1.84	0.10	-0.31	-0.31
Chile	1.14	1.72	1.17	-0.37	0.21	-0.05
Colombia	1.06	2.13	1.72	0.19	-0.48	-0.48
Costa Rica	1.10	1.73	1.89	0.17	0.19	0.28
Czech Republic	0.55	1.72	0.50	-0.002	-0.20	-0.23
Estonia	0.75	1.77	1.88	-0.05	-0.16	-0.17
Hungary	1.02	1.32	1.51	-0.29	-0.06	-0.25
Jamaica	0.98	2.60	2.64	-0.45	-0.55	-0.71
Mexico	1.86	2.13	1.00	-0.48	0.34	-0.17
Peru	1.81	2.13	1.14	-0.51	0.62	0.33
Slovenia	0.67	1.43	1.26	0.58	-0.46	-0.22
South Korea	1.47	2.72	2.55	-0.30	0.10	-0.07
Thailand	0.65	1.53	1.50	-0.30	0.15	0.02
Turkey	2.40	2.41	0.98	-0.07	0.04	-0.06
Average	1.24	2.09	1.72	-0.14	0.004	-0.12
USA	0.52	0.82	0.95	-0.38	-0.74	-0.85

Note: $\sigma(\tau^f)$, $\sigma(\tau^h)$, $\sigma(\tau^T)$ show the standard deviation of the firm component, the household component and the total labor wedge, respectively, relative to the standard deviation of output. $\rho(\tau^f)$, $\rho(\tau^h)$, $\rho(\tau^T)$ show the correlations of these component with the output.

FIGURE 1.2: The Decomposition of the Labour Wedge - Non-Separable Preference

1.7 Conclusion

In this study our aim was to show how far the various RBC models with permanent and transitory productivity shocks could take us in explaining the labour market fluctuations of business cycles in emerging countries, rather than to show a model that incorporates all extensions of the RBC could produce all labour market facts. Therefore, we first investigated labour market fluctuations in the business cycles of EMEs and compared these results with findings from the US for the period of 1970-2013. In the data we observed that the behaviour of labour market variables are not uniform across countries. Compared to the US, we found that on average real wages and productivity are very volatile but less volatile in terms of the quantities in the emerging countries.

Furthermore, we evaluated the performance of a standard RBC model in explaining labour market fluctuations in emerging countries. The simulation results show that the standard RBC model does reasonably well in matching the relative volatility of the hours worked in EMEs; however, it fails to account for the rest of the relevant moments in our analysis. In order to further improve the fit we introduce an RBC model augmented with real frictions. We found that each of these extensions improved the capability of the RBC model by manipulating a different economic dimension. Especially the model with investment adjustment cost improved the performance of the model in regard to the relative volatility of wages and hours, as well as the cyclicality of hours, compared to the standard RBC model for these countries. Lastly we investigated the cyclical behaviour of the labour wedge. We found that the labour wedge is more volatile in EMEs than in the US and the fluctuations in the labour wedge are mostly driven by fluctuations in the gap between the real wage and the MRS in both emerging countries and the US.

This study is helpful in revealing shortcomings of these models for EMEs and shows which directions the model needs to be modified to make it more consistent with the data. For future research we could bring the model implications very much in line with EMEs data by building a model augmented with labour market frictions such as wage rigidities, or a model that takes the informal sector into account. In order to improve the model's ability to match the data, further research is needed.

1.A Appendix: The Solution of Models

1.A.1 The Standard RBC Model

For non-separable utility function, the first-order conditions of consumption, hours and capital are respectively given by:

$$\lambda_t = \psi C_t^{\psi(1-\sigma)-1}(1-H_t)^{(1-\psi)(1-\sigma)} \tag{1.A.1}$$

$$(1-\psi)C_t = \psi(1-H_t)W_t$$

$$\lambda_t = \beta\lambda_{t+1}(1+R_{t+1}-\delta)$$

Since all the variables in 1.A.2 are stationary, we can compute a steady state, dropping time subscripts

$$\hat{Y} = \hat{K}^{1-\alpha}H^{\alpha}\mu_g^{\alpha-1} \tag{1.A.2}$$

$$\hat{W} = \alpha\hat{Y}/H$$

$$\hat{R} = (1-\alpha)\hat{Y}/\hat{K}\mu_g^{-1}$$

$$(1-\psi)\hat{C} = \psi(1-H)\hat{W}$$

$$1 = \beta{\mu_g}^{\psi(1-\sigma)-1}(1+R-\delta)$$

$$\hat{C}+\hat{K} = \hat{Y}+(1-\delta)\hat{K}{\mu_g}^{-1}$$

$$\hat{K} = (1-\delta)\hat{K}{\mu_g}^{-1}+\hat{I}$$

$$\hat{Y} = \hat{C}+\hat{I}$$

Here is the solution for the steady state of the model:

$$R = \frac{1}{\beta\mu_g^{\psi(1-\sigma)-1}} - (1-\delta) \tag{1.A.3}$$

$$\frac{Y}{K} = \frac{R}{(1-\alpha)\mu_g}$$

$$\frac{I}{Y} = \frac{K}{Y}(1-(1-\delta))\mu_g^{-1})$$

$$\frac{C}{Y} = 1-\frac{I}{Y}$$

$$H = (\frac{1-\psi}{\psi\alpha}\frac{C}{Y}+1)^{-1}$$

$$K = (\frac{H^{\alpha}\mu_g^{\alpha-1}}{\frac{Y}{K}})^{\frac{1}{\alpha}}$$

$$Y = K^{1-\alpha}H^{\alpha}\mu_g^{\alpha-1}$$

$$C = \frac{C}{Y}\,Y$$

$$I = \frac{I}{Y}Y$$

$$W = \alpha\,\frac{Y}{H}$$

For the separable utility function σ equals 1 in order to hold the balance of growth in the long run. For households the first-order conditions of consumption, hours and capital are given by

$$\lambda_t = C_t^{-1}, \tag{1.A.4}$$

$$\chi H_t^{\psi} = C_t^{-1}W_t$$

$$\lambda_t = \beta\lambda_{t+1}(1 + R_{t+1} - \delta)$$

respectively. We set the steady state of hours to 1 in order to find the value of χ in the steady state. The solution for the steady state for the separable utility function is

$$R = \frac{1}{\beta\mu_g^{-1}} - (1-\delta) \tag{1.A.5}$$

$$H = 1$$

$$\chi = C^{-1}W$$

The rest of the steady-state solutions for the variables are the same for the RBC model with the non-separable utility function.

1.A.2 The Standard RBC Model with Capacity Utilization

For non-separable utility function, the first-order conditions of consumption, hours, capital and utilization are given by

$$\lambda_t = \psi C_t^{\psi(1-\sigma)-1}(1-H_t)^{(1-\psi)(1-\sigma)} \tag{1.A.6}$$

$$(1-\psi)C_t = \psi(1-H_t)W_t$$

$$\lambda_t = \beta\lambda_{t+1}(1 + R_{t+1} - \delta X_t^{\Omega})$$

$$X_t = (\frac{1-\alpha}{\Omega\delta}\frac{Y_t}{K_t})^{1/\Omega}$$

respectively.

We set the steady state of utilization to 1 in order to find the value of Ω. The solution for the steady state of the model

$$X = 1 \tag{1.A.7}$$

$$R = \frac{1}{\beta\mu_g^{\psi(1-\sigma)-1}} - (1 - \delta X^{\Omega})$$

$$\Omega = \frac{R}{\delta}$$

$$\frac{I}{Y} = \frac{K}{Y}(1 - (1 - \delta X^{\Omega}))\mu_g^{-1})$$

$$K = (\frac{H^{\alpha}\mu_g^{\alpha-1}X^{1-\alpha}}{\frac{Y}{K}})^{\frac{1}{\alpha}}$$

$$Y = K^{1-\alpha}H^{\alpha}\mu_g^{\alpha-1}X^{1-\alpha}$$

The rest of the steady state values are the same for the standard RBC model.

1.A.3 The Standard RBC Model with Investment Adjustment Costs

Households maximize the Lagrangian, with two separate constraints

$$\mathcal{L} = \sum_{t=0}^{\infty}\beta^t U(C_t, H_t) + \lambda_t(W_tH_t + R_tK_t - C_t - I_t) +$$

$$\theta_t((1 - \frac{\phi}{2}(\frac{I_t}{I_{t-1}} - 1)^2)I_t + (1-\delta)K_t - K_{t+1}) \tag{1.A.8}$$

So the first order conditions of consumption, hours, capital and investment, are given by

$$\lambda_t = \psi C_t^{\psi(1-\sigma)-1}(1-H_t)^{(1-\psi)(1-\sigma)} \tag{1.A.9}$$

$$(1-\psi)C_t = \psi(1-H_t)W_t$$

$$\theta_t = \beta\lambda_{t+1}R_{t+1} + \beta\theta_{t+1}(1-\delta)$$

$$\lambda_t = \theta_t(1 - \frac{\phi}{2}(\frac{I_t}{I_{t-1}} - 1)^2 - \phi(\frac{I_t}{I_{t-1}} - 1)\frac{I_t}{I_{t-1}})$$

$$+ \beta\theta_{t+1}\phi(\frac{I_{t+1}}{I_t} - 1)(\frac{I_{t+1}}{I_t})^2$$

respectively.

Then we define Tobin's q as the shadow value of having an extra unit of capital, θ_t, and marginal utility of consumption, λ_t. If there is no adjustment cost (which means the adjustment cost ϕ equals to 0), then Tobin's q equals 1.

$$q_t = \frac{\theta_t}{\lambda_t} \tag{1.A.10}$$

From the Tobin's q equation, we already know that q_t λ_t equals θ_t. If we insert this equation into the FOC of capital and then divide both sides by λ_t , we get

$$q_t = \beta\frac{\lambda_{t+1}}{\lambda_t}((1-\delta)q_{t+1} + R_{t+1}) \tag{1.A.11}$$

Also, if we do the same process for the FOC of investment and then divide both sides by λ_t, we get

$$1 = q_t(1 - \frac{\phi}{2}(\frac{I_t}{I_{t-1}} - 1)^2 - \phi(\frac{I_t}{I_{t-1}} - 1)\frac{I_t}{I_{t-1}})$$

$$+ \beta q_{t+1}\frac{\lambda_{t+1}}{\lambda_t}\phi(\frac{I_{t+1}}{I_t} - 1)(\frac{I_{t+1}}{I_t})^2$$

There is no adjustment cost in the steady state so q equals 1. The solution to the steady state of the model with the investment adjustment cost: investment adjustment cost

$$q_t = 1, \tag{1.A.12}$$

$$R = \frac{1}{\beta\mu_g^{-1}} - (1-\delta)$$

$$\frac{I}{Y} = \frac{K}{Y}\frac{(1-(1-\delta))\mu_g^{-1})}{(1-\frac{\phi}{2}(\mu_g - 1)^2)}$$

The rest of steady state solution is the same as the steady-state solution for the basic RBC model.

1.A.4 The Standard RBC Model with Indivisible Labour

For households the first-order conditions of consumption, hours and capital are given by

$$\lambda_t = \beta C_t^{-1} \tag{1.A.13}$$

$$Bc_t = w_t$$

$$\frac{1}{c_t} = \beta \frac{1}{c_{t+1}}(1 + r_{t+1} - \delta)$$

Lastly, the steady state of hours is:

$$H = \alpha(\frac{C}{Y})^{-1}\frac{1}{B} \tag{1.A.14}$$

1.B Appendix: Additional Tables

Table 1.6: Time Covered By Country

Country	Employment	Hrs. Wrk.,Prod.	Wages	Output
Brazil	1970-2013	1970-2013	1992-2009	1970-2013
Bulgaria	1970-2013	1995-2013	1996-2011	1970-2013
Chile	1970-2013	1970-2013	1974-2013	1970-2013
Colombia	1970-2013	1970-2013	1970-2012	1970-2013
Costa Rica	1970-2013	1987-2013	1987-2012	1970-2013
Czech Republic	1970-2013	1993-2013	1994-2008	1985-2013
Estonia	1970-2013	2000-2013	2000-2013	1980-2013
Hungary	1970-2013	1980-2013	1995-2008	1970-2013
Jamaica	1970-2013	1986-2013	1998-2013	1970-2013
Mexico	1970-2013	1970-2013	1980-2011	1970-2013
Peru	1970-2013	1970-2013	1970-2011	1970-2013
Slovenia	1970-2013	1996-2013	1996-2009	1980-2013
South Korea	1970-2013	1970-2013	1970-2008	1970-2013
Thailand	1970-2013	1970-2013	1970-2012	1970-2013
Turkey	1970-2013	1970-2013	1987-2006	1970-2013

Table 1.7: Descriptive Statistics for Emerging Countries on Average and the USA

Variables	Mean	Std. Dev.	Var.	Median
Employment	4.14(4.24)	0.08(0.05)	0.007(0.002)	4.15(4.26)
Hours worked(he)	7.59(7.46)	0.48(0.02)	0.003(2.70E-04)	7.14(7.46)
Hours worked(hw)	7.12(7.09)	0.06(0.04)	0.005(0.001)	7.12(7.12)
Productivity	2.08(3.37)	0.22(0.21)	0.80(40.51)	2.53(28.57)
Wages	10.52(3.06)	0.28(0.08)	0.13(0.006)	10.51(3.02)
Output	9.16(10.47)	0.23(0.23)	0.07(0.05)	9.14(10.47)

Note: The descriptive statistics for the US appear in parentheses.

Chapter 2

Technology Shocks, Non-stationary Hours in Emerging Countries and DSVAR

2.1 Introduction

Many dynamic macroeconomic models should be able to match data across all frequencies since they have generated business cycle fluctuations as well as long-run growth paths. Around this path output, consumption and investment grow at the same rate while great ratios (such as consumption to output ratio) and hours are stationary.[1] However, the data clearly show that hours worked per capita are highly persistent and non-stationary during the past four decades in emerging market economies (EMEs) which are shaped by both extensive (the employment ratio) and intensive (hours per worker) margins but it is apparent that it is mostly shaped by movements in the extensive margin.[2] Then, these models are not able to reproduce impulse response functions (IRFs) obtained from empirical models in EMEs such as VARs. In this paper, we identify a mechanism that enables a standard DSGE model to fit non-stationary hours worked data in EMEs, while preserving the property of a balance growth path and then test this model on impulse responses of hours worked and real GDP after technology and non-technology shocks in these economies.

Motivated by these facts and the patterns observed in the data used for this study, we first estimate a SVAR model with a specification of hours in difference (DSVAR) from 1970 to 2013 and then build a DSGE model in which hours have a stochastic trend, including two permanent shocks. In addition to a permanent technology shock, the

[1] See King, Plosser, and Rebelo (1988) for the restrictions on technology and preferences that satisfy the balanced growth path property.

[2] See Figure 2.1 in data section. We also find that the standard unit root test results do not reject the hypothesis that the hours series has a unit root. We provide more details about it in data section.

model includes labour supply shocks which yield non-stationary hours as in Chang, Doh, and Schorfheide (2006). One of the reasons hours could be non-stationary is because there might be a labour supply shock (LS) in these economies. Our research suggests that these LS shocks could be associated with very dramatic changes in labour supply that look permanent following changes in demographic structure, in home and market production and in labour market participation, especially in female labour participation. For instance; when studying the data on male and female labour participation in these economies between 1990-2015, it is possible to see that female labour participation has significantly increased in Brazil from 44% to 57%, in Chile from 32% to 58%, in Colombia from 31% to 58% and in Peru from 46% to 68% (see data section for further evidence).

Regarding the theoretical model, we impose long-run restrictions (Blanchard and Quah (1989)) to identify structural VARs and then compute the impulse responses of hours and real GDP[3] for each emerging country. The identification restriction comes from the fact that both technology and LS shocks have a permanent effect on GDP yet only the LS shocks have a permanent impact on the hours worked. We have some degree of confidence that our model accurately reflects basic features of these economies because the restriction on the DSGE and the DSVAR are consistent with the pattern of long run growth in emerging economies. In addition, the consumption to output ratio seems to be balanced in these economies.[4] Hence, it cannot be that technology shocks derive non-stationary hours.[5] That is, to match the growth facts in EMEs, we generate non-stationary hours by LS shocks using log utility in consumption. In that case, the VAR identification we made would be valid as hours are stationary to technology shocks. The way we test the implications of the model is to compare the empirical impulse response functions (IRFs) to those obtained from running an identical DSVAR on model generated data of the same length as the actual data. The literature calls this the Sims-Cogley-Nason approach because it has been advocated by Sims (1980) and applied by Cogley and Nason (1995). It involves treating the data from the actual economy and model economy symmetrically.[6]

Under these identification restrictions and this economic interpretation, LS and technology shocks seem to have a positive permanent impact on GDP in almost all emerging economies. Moreover, a technology shock does not have any long run impact on hours

[3]It is widely accepted that GDP is characterized as a unit root process

[4]We observe that, in the data, the behaviour of the C/Y ratio in these economies is stationary in Appendix 2.C. Note that we examine the long run movements in the C/Y ratio in terms of current prices rather than constant prices because we have one sector model.

[5]Non-stationary hours and the long-run impact of technology shocks on GDP are compatible with the DSVAR adopted by Gali (1999) and Gali and Rabanal (2005).

[6]The literature calls this approach as the Indirect Inference which uses an auxiliary model in order to indirectly test a DSGE model. See Minford, Wickens, and Xu (2016), who compare Indirect Inference tests based on IRFs with those based on VAR coefficients. See also Canova and Sala (2009), who particularly concerned with measures of model closeness to the IRFs found in the data. Chari, Kehoe, and McGrattan (2008) contend that this approach is certainly more promising compared to the Direct Inference.

(by assumption) as it temporarily declines after a technology shock in Brazil, Hungary and Turkey. However, for Chile, Colombia, Mexico, Peru, Sri Lanka, South Africa and Thailand, a technology shock increases the hours worked. Besides, a labour supply shock has a positive long run impact on hours worked for all these economies although it is not significant. To ensure that the VAR procedure works well, the consumption to output ratio (C/Y) is added. Gospodinov (2010) explains that this ratio is a good candidate for inclusion in VAR since it improves the identification of the technology shocks, and it is not subject to any controversy in the literature. Augmenting the specification with an additional variable does not change the results much in most cases. However, the results appear more significant when compared to the two-variable VAR models.

We then estimate a DSVAR model on simulated data from the DSGE model and compute the IRFs of hours and real GDP to technology and LS shocks using long-run restrictions. We observe that hours worked increases permanently after a positive LS shock but it decreases temporarily after a positive technology shock. Moreover, real GDP rises permanently after a positive technology shock but following a positive LS shock it decreases in the beginning of the period and then rises permanently. Our results show that the VAR is not able to capture the significant impulse responses of the benchmark model. For robustness, we first build a production technology with the permanent labour-augmenting productivity shock, which represents the cumulative product of "growth shocks" (see Aguiar and Gopinath (2007)). We then build a DSGE model with a productivity technology shock and a labour supply shock which captures the rate of growth shock. We observe that our VAR model performs better to capture the dynamic responses of GDP and hours to both shocks in these models. The overall results show that our models are able to indirectly mimic IRFs obtained from a DSVAR on the actual data although our DSVAR specification poorly identifies the impulse responses of hours worked and real GDP to both shocks. Therefore, we can conclude that a DSGE model with permanent LS shocks that can generate a unit root in hours worked is required to properly evaluate the DSVAR in EMEs as the data support this view.

In the literature, many researchers doubt that hours worked are stationary as they have observed apparent changes in labour supply patterns.[7] Therefore, they have been particularly concerned with this issue. For example, Shapiro and Watson (1988) have shown that half of the changes in output can be accounted for by the non-stationary behaviour in hours worked.[8] Moreover, in response to a provocative finding by Gali (1999) that a technology shock tends to decrease the hours worked in the US as well as in

[7]See McGrattan and Rogerson (2004), Gali (2005) and Boppart and Krusell (2016)'s work. These studies are related to the US.

[8]As noted by Hall (1997), cited in Gali (2005), preference shifts are identified as the most significant driving force of change in total working hours. Furthermore, Chang and Schorfheide (2002) have confirmed the relevance of labour supply shocks at business cycle frequencies and find that labour supply shifts account for about 30% of the variation in hours and about 15% of the output fluctuations at business cycle frequencies.

other G7 countries.[9] However, Christiano and Eichenbaum (1992) find that hours worked increase after a positive technology shock. They show that the statistical inference in SVAR depends on the treatment of hours worked (first-differences vs. levels). These findings have renewed the debate on the relative contributions of various shocks to the business cycle as well as having led researchers in the SVAR literature to draw discernibly contrasting inferences. To illustrate, Gali and Rabanal (2005) (p.5) state that "the bulk of evidence provides little support for the initial claims of the real business cycle literature on the central role of technological change as a source of business cycles". Moreover, Francis and Ramey (2005b) argue that business cycle models are dead while Christiano and Eichenbaum (1992) claim that they are alive. However, Cantore, Leon-Ledesma, McAdam, and Willman (2014) analyze the impact of technology shocks on hours worked by introducing a Constant Elasticity of Substitution (CES) production technologies and factor-biased technology shocks in both RBC and NK models. They reveal that the sign of the response of hours depends on the magnitude of the elasticity of capital-labour substitution and the factor-augmenting nature of shocks in these models. They find that "both models can generate technology-hours responses of either sign" (see also Cantore, Ferroni, and Leon-Ledesma (2017)).

In our paper, we do not quantify the contribution of LS shocks in explaining business cycle fluctuations in the context of a VAR model and do not focus on hours-technology debate on the treatment of hours worked. We test the hypothesis of a permanent LS shock that can produce non-stationary hours worked, and find that this view confronts with the data. We maintain the structural interpretation of our identified shocks as an open question. However, they should not be dismissed as potential drivers of business cycle fluctuations in EMEs as these economies provide a unique environment to study the effect of these shocks. Therefore, it is important to disentangle the different shocks, provide a theoretical set-up where this is feasible for EMEs and then test the model on impulse responses of hours worked and real GDP after technology and non-technology shocks in these economies. Lastly, we observe that the long run behaviour of hours worked is more pronounced in EMEs compared to the USA (see Appendix 2.A) as there is more scope for changes coming from labour participation decisions to drive fluctuations in EMEs. Therefore, we believe that our model is more suitable for EMEs.

The remainder of this paper is organized as follows. In section 2.2, we present data. In section 2.3, we describe the empirical framework. Section **??** presents the results for balanced and non-balanced growth. Section 2.4 lays out the DSGE model with non-stationary hours. Section 2.5 presents calibration. Section 2.6 documents the results. Finally, section 2.7 provides concluding remarks.

[9] Many other papers reach conclusions that complement Gali's findings in different ways. See Basu, Fernald, and Kimball (2004), Gali (2004), Gali (2005), Francis and Ramey (2005a), Francis and Ramey (2005b), Gali and Rabanal (2005), Dupaigne, Feve, and Matheron (2005).

2.2 Data

Annual data from 1970 to 2013 are collected for ten emerging market economies (Brazil, Chile, Colombia, Hungary, Mexico, Peru, South Korea, Sri Lanka, Thailand, and Turkey) and the US.[10] We chose countries based on the availability of data as it is difficult to find quality data for these economies. However, we believe that we have sufficient annual data for this analysis. As we already mentioned in the first chapter, there might be a measurement error in the data as we could not obtain significant impulse responses from our data. Our results could be more significant if we use quarterly data but it is not possible to find quarterly hours worked data for these economies. The data on GDP (total GDP, in millions of 1990 US dollars), hours worked, employment and population (the population aged 15-64) are compiled from the Conference Board Total Economy Database (TED).[11] Hours worked per working age population are constructed using total hours worked and working age population.[12] To calculate the consumption to output ratio, household consumption expenditure data are used at current prices in US dollars, including non-profit institutions serving households, which are collected from the United Nation Statistics Division, which publishes data on national accounts and the data on GDP (total GDP, in millions of current US dollars) are compiled from the TED. To estimate the model, the variables are constructed on a per capita basis and transformed by taking natural logs.

We now go over the hours worked data from various perspective across time. Figure 2.1 shows the behaviour of total hours worked in EMEs from 1970 to 2013. We observe that there is a significant heterogeneity in the behaviour of hours in these economies. It displays a clear upward trend in Colombia, Peru and Sri Lanka while a persistent decline can be seen in the case of Hungary, South Africa and Turkey. To understand why changes in labour supply might be driving aggregate hours, the changes in total hours at the extensive (employment rate) and intensive (average hours per worker) margins are also illustrated in this figure. We find that total hours worked are shaped by both margins but it is obvious that it is mostly shaped by the movements in the extensive margin for all these economies.

This makes us explore more about what drives the changes in extensive margin. Therefore, the changes in the extensive margin for both males and females between 16

[10] Francis and Ramey (2004), Gali (2005) and Chaudourne, Feve, and Guay (2014) also estimate a SVAR with long run identifying restrictions using annual time series data for the U.K., G7 countries, and the US, respectively.

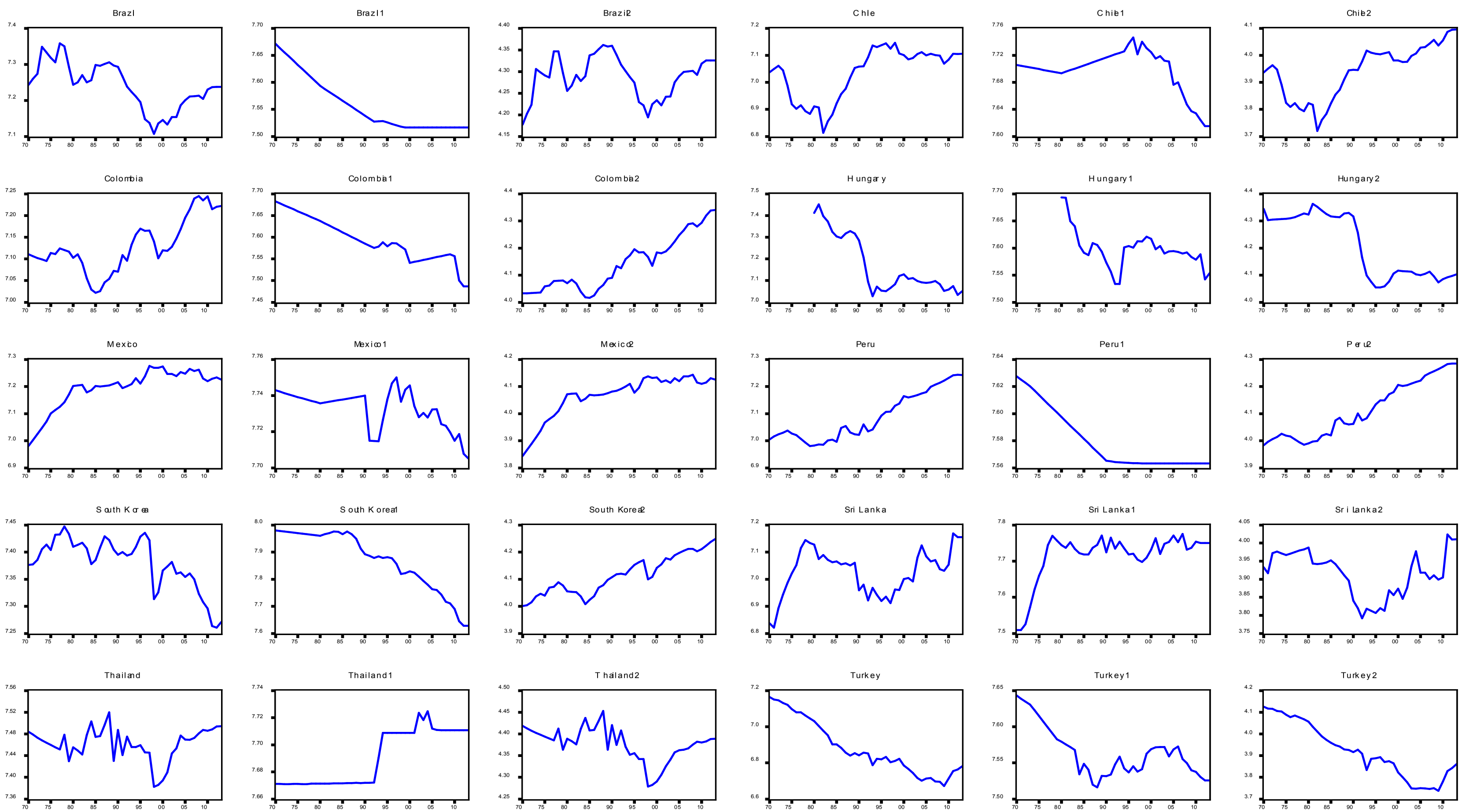
[11] The University of Groningen compiles the figures from national labour force surveys and national establishment surveys as well as from international sources. In addition, the Conference Board and Groningen Growth and Development Centre is the main source of estimates of hours worked per worker that is comparable across countries. More specifically, these series are adjusted to reflect most sources of cross-country variation in hours worked, including the contracted length of the work week, statutory holidays, paid vacations, sick days and days lost due to strikes, and they are consistent with the output.

[12] The more details on our calculations can be found in first chapter.

and 64 years and the total in Figure 2.2 are presented. For this, the data on employment to population ratio (the population aged 15-64) are compiled from the OECD database for Brazil (2001-2014), Chile (1996-2016), Colombia (2001-2016), Hungary (1992-2016), Mexico (1991-2016), Korea (1980-2015) and Turkey (1989-2015). It can be seen that the movements in the extensive margin for females contribute more to the variations in aggregate hours as the employment rate has been changing more for women than for men in these economies. More specifically, the extensive margin for women has increased notably in emerging countries included in our analysis such as in Brazil, from 51% to 57% between 2002 and 2014; in Chile, from 35% to 53% between 1996 and 2015; and in Mexico, from 34% to 46% between 1992 and 2015. In Appendix 2.A, we are only able to look at the changes of intensive margins by gender in Mexico since it was not possible to obtain data for the other emerging economies. The data has been collected from INEGI (Instituto Nacional De Estadistica Y Geografia) from 1990 to 2015. It shows that there is a significant increase in the female intensive margin in Mexico between 1990 and 2015 while the male intensive margin dropped substantially between 2000 and 2006.

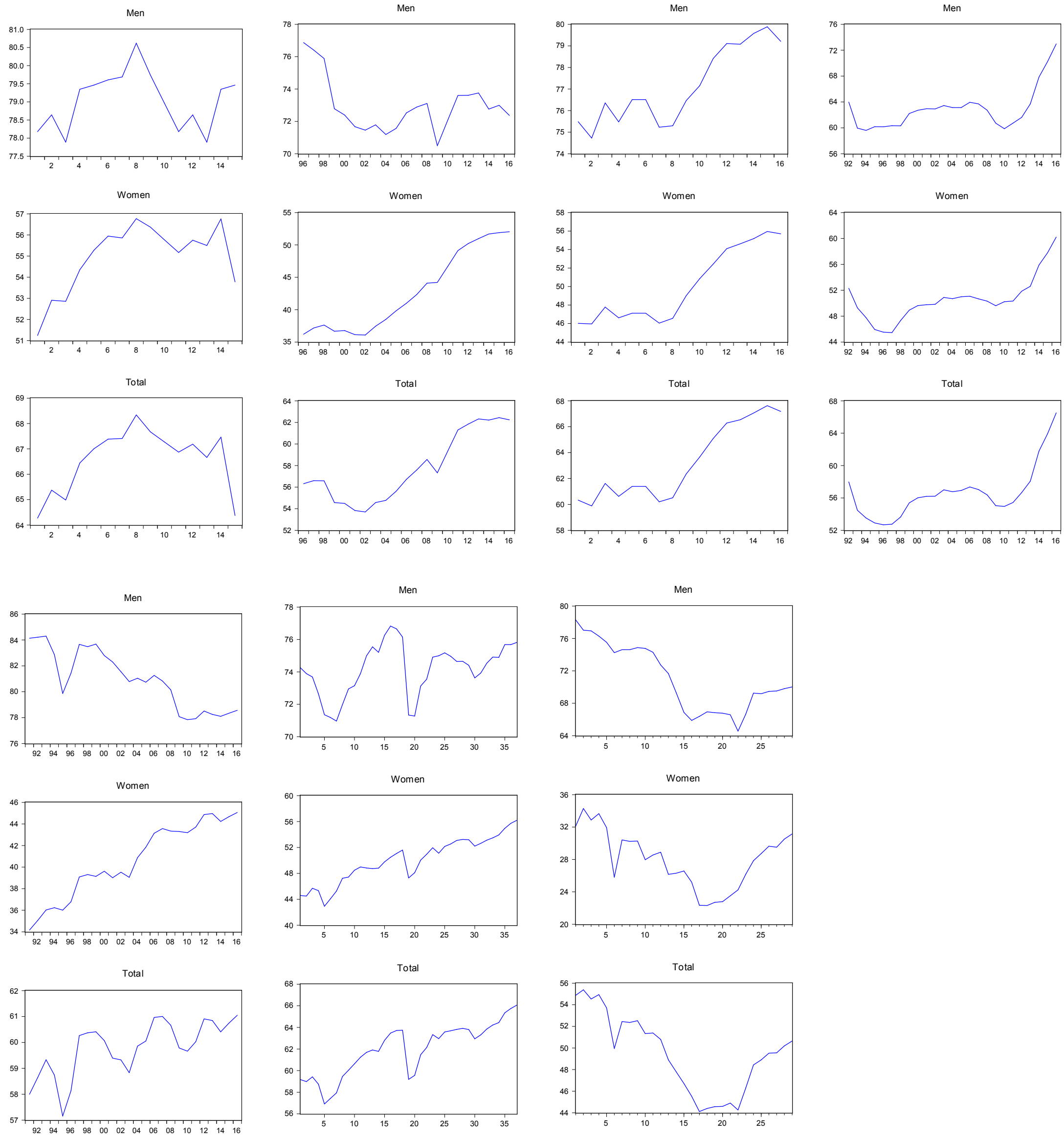
Lastly, the facts about the variations in home and market production are observed for available emerging market economies. The data for total weekly paid and unpaid work time (the sample included those between 15 and 64 years) are obtained from Bridgman, Duernecker, and Herrendorf (2015) for Korea (1970-2014) and Mexico (1992-2014). It is, thus, only possible to examine the home and market production hours for a few emerging economies, but this still enables an understanding of the changes in hours worked. The data shows that the average weekly hours of household work in Korea and Mexico decreased from 20.8% to 10.4% and from 34.6% to 29.9%, respectively. However, market production increased from 28% to 32% in Korea and from 30% to 35% in Mexico. In addition, there was a decrease in home production (from 53% to %46) for women but an increase in market production (from 15% to 20%) in Mexico. All these changes might be attributed to labour supply shocks and may reflect permanent shifts in hours worked.

FIGURE 2.1: The Fluctuations of Total Hours Worked, Intensive Margin and Extensive Margin



Note: This figure displays the fluctuations of total hours worked, intensive and extensive margins for the period 1970-2013. Note that the first figures represent total hours worked (e.g. Brazil), second figures display intensive margin (e.g. Brazil1) and third figures represent extensive margin (e.g.Brazil2). All variables are in per capita terms and are logged.

Figure 2.2: The Fluctuations in Extensive Margin by Gender for Emerging Market Economies



Note: This figure shows the fluctuations in extensive margin by gender for EMEs. The countries from left to right: Brazil (2001-2015), Chile (1996-2016), Colombia(2001-2016), Hungary (1992-2016), Mexico (1991-2016), Korea (1980-2016) and Turkey (1988-2016). All variables are logged.

The Augmented Dickey-Fuller (ADF) tests of the null hypothesis of non-stationarity and the KPSS (Kwiatkowski-Phillips-Schmidt-Shin) tests for stationarity on hours worked are presented in Table 2.1. The test results show that one cannot reject the hypothesis of a unit root (except for Mexico) and one can reject the hypothesis of stationarity at a very high significance level (except Sri Lanka and Thailand) for many emerging economies. In addition, the same battery of ADF and KPSS tests applied to our GDP series supports the existence of a unit root and stationarity, respectively (see Appendix 2.A). Finally, we observe that the test results provide support for the first-difference specification. Thus, we specify our variables as first differences in the VAR model in section 2.3.

TABLE 2.1: Tests of Non-stationarity and Stationarity

Countries	H_1	10%/5%/1%	H_2	10%/5%/1%
Brazil	-1.32	-3.59/-2.93/-2.60	1.37	0.74/0.46/0.35
Chile	-0.81	-3.59/-2.93/-2.60	1.32	0.74/0.46/0.35
Colombia	-0.35	-3.59/-2.93/-2.60	1.39	0.74/0.46/0.35
Hungary	-2.98	-3.59/-2.93/-2.60	1.34	0.74/0.46/0.35
Mexico	-3.64	-3.59/-2.93/-2.60	1.66	0.74/0.46/0.35
Peru	0.73	-3.59/-2.93/-2.60	2.08	0.74/0.46/0.35
South Korea	-0.79	-3.59/-2.93/-2.60	1.37	0.74/0.46/0.35
Sri Lanka	-1.95	-3.59/-2.93/-2.60	0.32	0.74/0.46/0.35
Thailand	-1.88	-3.59/-2.93/-2.60	0.19	0.74/0.46/0.35
Turkey	-2.76	-3.59/-2.93/-2.60	2.05	0.74/0.46/0.35
USA	-2.25	-3.59/-2.93/-2.60	0.81	0.74/0.46/0.35

Note: This table presents the results for ADF unit root test (H_1) and KPSS tests of stationarity (H_2). t-statistics for the null hypothesis of a unit root and stationarity in the log-level of hours worked base on an ADF test and KPSS test with one lag and intercept. We choose 1%, 5%, and 10% level as critical values. Sample period 1970-2013.

Given that the data sample is annual, two lags are used following the convention in the literature.[13] However, for a robustness check, we also check impulse response functions estimated using lags selected by the Akaike Information Criterion (AIC), the Schwarz Information Criterion (SIC), and Final Prediction Error (FPE) to determine the appropriate number of lags for our VAR model and then allow the lag length for each country. We start with a maximum of three lags. These tests show that one lag needs to be considered for Chile, Peru, and Thailand, whilst two are required for Brazil, Mexico, South Korea, and the USA, and three are needed for Hungary, Sri Lanka, and Turkey.

2.3 Methodology

In this section, the focus is on the structural vector autoregressions (SVAR) procedure, which treats all variables as endogenous and uncovers the statistical process that might

[13]See Basu, Fernald, and Kimball (2004) and Chaudourne, Feve, and Guay (2014)'s work who use two lags for annual data in a VAR.

have generated the observable data, with the well known long run restrictions. It has become a standard tool since the pioneering research by Blanchard and Quah (1989) (henceforth BQ). They propose an identification scheme based on long-run restrictions, which is used to show that demand shocks have no effect on the long-run levels of output, while supply shocks can have a permanent effect on it. This procedure has recently been used in the literature by Gali (1999), Francis and Ramey (2005a), Gali and Rabanal (2005) and Chari, Kehoe, and McGrattan (2008).

The first step for the analysis of an SVAR is the estimation of a reduced form VAR:

$$D(L)X_t = \epsilon_t \qquad E(\epsilon_t \epsilon_t^{'}) = \Omega, \tag{2.3.1}$$

where $D(L) = D_0 + D_1 L + D_2 L^2 + ... + D_p L^p$ and L is the lag operator with $L^i X_t = X_{t-i}$. As 2.3.1 is a reduced form, D_0 is equal to the identity matrix I. X_t is a vector of containing log hours worked (h_t) and real $GDP(y_t)$. In the previous section, we applied the ADF and KPSS tests to our variables and outcomes verified that h_t and y_t are non-stationary. Given these findings, we must ensure that these variables into the VAR such that $\triangle log(h_t)$ is the first difference in the log of hours and $\triangle log(y_t)$ is the first difference of the log of real GDP. We invoke that these variables are driven by two shocks, labour supply shocks, ϵ_t^{LS}, and technology shocks, ϵ_t^{TS}, respectively. The covariance matrix of reduced form residuals ϵ_t is non-diagonal, and hence, it is clear that the shocks in ϵ_t cannot be the structural innovations which are assumed to be uncorrelated with each other. That is, the reduced form error terms ϵ_t have no structural interpretation.

When the VAR is invertible in equation 2.3.1, the variables can be expressed as a moving average (MA) representation of the innovations ϵ_t:[14]

$$X_t = C(L)\epsilon_t, \tag{2.3.2}$$

where $C(L) = D(L)^{-1}$. Now suppose that the VAR representation of the structural form can be written as:

$$B(L)X_t = u_t \qquad E(u_t u_t^{'}) = I. \tag{2.3.3}$$

where u_t are orthogonal structural disturbances, which have been normalized so as to have unit variance, cov(u_t)=I. If the matrix polynomial $D(L)$ is invertible, so is the matrix polynomial $B(L)$ and then the MA representation with the structural shocks

[14] If a DSGE model cannot be represented by a SVAR it is called non-invertible (see Sims (2012)'s study).

takes the following form:

$$X_t = A(L)u_t. \tag{2.3.4}$$

Note that $A(L) = B(L)^{-1}$. The structural MA representation in 2.3.4 is also called the final form of an economic model because the endogenous variables X_t are expressed as distributed lags of the exogenous variables, given by the elements of u_t. However, we cannot directly observe the structural shocks. We can observe the exogenous structural shocks u_t by first estimating the reduced form VAR (2.3.1) and transforming the reduced form residuals. From 2.3.2 and 2.3.4 we have:

$$A(L)u_t = C(L)\epsilon_t. \tag{2.3.5}$$

As $C_0 = I$ and 2.3.5 must hold for all t, we have:

$$A_0u_t = \epsilon_t. \tag{2.3.6}$$

It follows that:

$$A_0A_0^{'} = \Omega, \tag{2.3.7}$$

It is obvious from 2.3.7 that the matrix A_0 has to be of full rank. Combining 2.3.5 and 2.3.6, we obtain:

$$A(L)u_t = C(L)A_0u_t, \tag{2.3.8}$$

which implies:

$$A_i = C_iA_0. \tag{2.3.9}$$

Note that knowledge of A_0 is sufficient for the full identification of the structural system. That is, when A_0 is known, all structural coefficients of the lag polynomial A(L) and the structural innovations u_t can be calculated from the estimated reduced form VAR using 2.3.6 and 2.3.9. Identification requires choosing the n^2 elements of A_0. With a two-variable system, the A_0 matrix consists of four elements, which necessitates four restrictions for identification. Structural shocks are supposed to be mutually uncorrelated, and therefore, the variance-covariance matrix of the structural shocks need to be diagonal,[15] which yields n(n+1)/2 restrictions on the elements of A_0, thereby imposing three restrictions on the elements of A_0. Additional n(n-1)/2 restrictions are needed to fully identify A_0. From the theory model, we can impose the necessary restrictions following Blanchard and Quah (1989), who used long run restrictions in order to identify structural VARs.

[15]Note that the standard deviations of the structural shocks are normalized to 1, i.e. the variance-covariance matrix of the structural shocks is set to the identity matrix.

$$\begin{bmatrix} \triangle log(h_t) \\ \triangle log(y_t) \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) \\ A_{21}(L) & A_{22}(L) \end{bmatrix} \begin{bmatrix} u_t^{LS} \\ u_t^{TS} \end{bmatrix}$$

The long-run restriction makes $A_{12}(1) = 0$. In other words, the matrix of long run multipliers A(1) is assumed to be lower triangular. We observe that one of the primary components of the business cycle might be labour supply shocks that can produce long-run changes in hours worked as we observe discernibly the variations in labour supply patterns in EMEs. Therefore, the identifying assumption imposed in the DSVAR is that labour supply shocks, u_t^{LS} are the only ones that can have an accumulated long run effect on hours. Moreover, both LS and technology shocks have permanent effects on real GDP.[16]

2.4 A DSGE Model as Data Generating Processes

In this section, our aim is to present an economic theory to test the claim made for the DSVAR procedure with long run restrictions. Specifically, we present the models that are used to generate the simulated data for 1,000 series for hours worked and GDP and then drop the first 956 for each variable in order to eliminate the effect of initial conditions. Later, we apply the DSVAR procedure to these data to see whether the BQ procedure reveals the actual impulse response functions for emerging countries.[17]

As a benchmark, we build a DSGE model with non-stationary hours, due to a permanent preference shock (B_t), along the lines of Chang, Doh, and Schorfheide (2006).[18] The model is real and perfectly competitive. Households consume, accumulate physical capital, and supply labour and capital to firms. In addition, there is a technology shock (A_t) which evolves according to a random walk as in a labour supply shock (B_t).

For robustness, we also present a DSGE model with a productivity shock as a rate of growth shock as in Aguiar and Gopinath (2007). We are interested in their shock because they find that the business cycles in emerging countries are mainly driven by shocks to trend growth rather than transitory fluctuations around a stable trend. Finally, we build a DSGE model with both a productivity shock and a labour supply shock as a rate of

[16]For more detailed information about SVAR methodology, please click on the following links: `https://pdfs.semanticscholar.org/3954/71508a4d2e3fedf1f3a78ca15b11820916df.pdf` and `https://www.files.ethz.ch/isn/124218/kap1072.pdf`.

[17]The distinctive feature of Indirect Inference is to use an auxiliary model in order to indirectly test a DSGE model. See Canova and Sala (2009) who are particularly concerned with measures of model closeness to the IRFs found in the data. See also Minford, Wickens, and Xu (2016) who compare Indirect Inference tests based on IRFs with those based on VAR coefficients.

[18]Although non-stationary hours receive empirical support, modelling hours as non-stationary is highly controversial since the maximal number of hours that a person can work in a day is bounded and thus is stationary. Hence, no model taking into account this physical constraint can yield a unit root process for the logarithm of hours (see Francis and Ramey (2005a); Chari, Kehoe, and McGrattan (2008) and Chaudourne, Feve, and Guay (2014)). However, Gali (2005) argues that stationary (per capita) hours is not a necessary condition for these models to generate a balanced growth path.

growth shock. Note that these models satisfy completely the identifying assumption of the DSVAR specification in previously estimated in section 2.3, this being only labour supply shocks have a long run effect on hours.

2.4.1 The Household Problem

The representative household maximizes the expected discounted lifetime utility function from consumption C_t and hours worked H_t:

$$E_0\left[\sum_{t=0}^{\infty}\beta^t\left(\ln C_t - \frac{(H_t/B_t)^{1+1/\psi}}{1+1/\psi}\right)\right]. \tag{2.4.1}$$

$E\,(.)$ denotes the expectation operator, conditional on information available at time t, β is the discount factor between zero and one. The Frisch labour supply elasticity is ψ. The log utility in consumption C_t implies a constant long-run labour supply in response to a permanent change in technology as we discussed earlier. Absent this constraint, the upward trend of real wages would induce a positive or negative trend in hours worked and then consumption to output ratio will be non-stationary, contrary to the long run growth facts in EMEs. H_t represents the hours worked, which are subject to a labour supply shock, denoted by B_t. If there is an increase in B_t, it leads to a rise in aggregate hours worked. This may reflect permanent changes in hours worked due to demographic changes, tax reforms, shifts in the marginal rate of substitution between leisure and consumption, and technological changes in household production technology (see Chang, Doh, and Schorfheide (2006)' work).

A household is assumed to own capital, K_t, which accumulates according to the following law of motion:

$$K_{t+1} = (1-\delta)\,K_t + I_t, \tag{2.4.2}$$

where I_t denotes investment, and δ is the depreciation rate of capital.

The households are subject to the following inter-temporal budget constraints:

$$C_t + I_t = W_t H_t + R_t K_t, \tag{2.4.3}$$

where W_t denotes a household's real wage rate, and R_t represents the rental rate of capital.

Consumers choose to maximize utility, subject to capital accumulation and their budget constraint:

$$C_t + K_{t+1} = W_t H_t + R_t K_t + (1-\delta)\,K_t. \tag{2.4.4}$$

2.4.2 The Firms Problem

The representative firm rents capital, hires labour, and produces final goods according to the following Cobb-Douglas technology:

$$Y_t = K_t^{1-\alpha}(H_t A_t)^{\alpha}, \tag{2.4.5}$$

where Y_t is output and α is the share of labour. The stochastic process A_t represents the exogenous labour augmenting technical progress.

Profit maximization of the firm and factor market equilibrium conditions determine the wage rate W_t and rental rate R_t:

$$R_t = (1-\alpha)\,(\frac{K_t}{H_t})^{-\alpha} A_t^{\alpha}, \tag{2.4.6}$$

$$W_t = \alpha\,(\frac{K_t}{H_t})^{1-\alpha}\,A_t^{\alpha}.$$

We assume that the log production (permanent) technology A_t and labour supply shock B_t evolve according to a random walk:

$$\ln A_t = \ln A_{t-1} + \varepsilon_{a,t}\,, \tag{2.4.7}$$

$$\ln B_t = \ln B_{t-1} + \varepsilon_{b,t}\,. \tag{2.4.8}$$

$\varepsilon_{a,t}$ and $\varepsilon_{b,t}$ represent an independent and identical distribution drawn from a normal distribution, with a zero mean and standard deviation σ_a and σ_b, respectively. We use A_0 and B_0 to denote the initial level of A_t and B_t, respectively. Note that these shocks are orthogonal by construction. In this model, the B_t induces a stochastic trend into hours, output, consumption, capital. In addition, A_t has a long-run impact on output, consumption, and capital but not on hours. That is, B_t is the only source of a stochastic trend in hours, while both shocks are the source of a stochastic trend in GDP.

2.4.3 Equilibrium Conditions in Stationary Form

To obtain a stationary equilibrium, the variables have to be de-trended according to:

$$\hat{H}_t \equiv \frac{H_t}{B_t}, \hat{Y}_t \equiv \frac{Y_t}{A_t B_t}, \hat{C}_t \equiv \frac{C_t}{A_t B_t}, \hat{K}_t \equiv \frac{K_t}{A_t B_t}$$

With these transformations, we have the following equilibrium dynamics of the endogenous variables in the neighborhood of the steady state:[19,20]

Cobb-Douglas production function:

$$\hat{Y}_t = \hat{K}_{t-1}^{1-\alpha} H_t^{\alpha} (\frac{A_t B_t}{A_{t-1} B_{t-1}})^{\alpha-1}, \tag{2.4.9}$$

Labour demand:

$$\hat{W}_t = \alpha \hat{Y}_t / H_t B_t,$$

Demand for capital:

$$R_t = (1-\alpha)\hat{Y}_t / \hat{K}_{t-1} (\frac{A_t B_t}{A_{t-1} B_{t-1}}),$$

Labour supply :

$$\hat{H}_t^{1/\psi} = \hat{C}_t^{-1} \hat{W}_t,$$

Euler for capital:

$$\hat{C}_t^{-1} = \beta (\hat{C}_{t+1})^{-1} (\frac{A_t B_t}{A_{t+1} B_{t+1}})(1 + R_{t+1} - \delta),$$

Law of motion for capital:

$$\hat{K}_t = (1-\delta)\hat{K}_{t-1} (\frac{A_t B_t}{A_{t-1} B_{t-1}})^{-1} + \hat{I}_t,$$

Aggregate resource constraints:

$$\hat{C}_t + \hat{K}_t = \hat{Y}_t + (1-\delta)\hat{K}_{t-1} (\frac{A_t B_t}{A_{t-1} B_{t-1}})^{-1},$$

$$\hat{Y}_t = \hat{C}_t + \hat{I}_t.$$

[19] We put non-linear equations into dynare, which log-linearizes them. See Dupaigne, Feve, and Matheron (2007) and Chang, Doh, and Schorfheide (2006)'s work. They solve the approximate solution of the model by computing from a log-linearization of the stationary equilibrium conditions around the deterministic steady state.

[20] See Appendix 2.B for the first order conditions of the model and steady states of the respective variables for the benchmark model.

2.5 Calibration

We parametrize the parameter values that are familiar from the business cycle literature due to lack of quality data for annual frequency in emerging countries. Therefore, we have relied on highly conventional parameters widely used in the DSGE models of annual frequency for the US. These values are fitted for emerging countries. Table 2.2 reports all parameters of the model.

TABLE 2.2: Parameter Values in Models

Parameters	Definition	Value
β	The discount factor	0.95
ψ	The inverse of the Frisch elasticity of labour supply	0.33
α	The labour share of output	0.68
δ	The depreciation rate of capital	0.07
μ	The long run average growth rate of shocks	log(1.0066)
ρ	The persistence of growth shocks	0.01
σ_a	The standard deviation of technology shocks	0.012
σ_b	The standard deviation of labour supply shocks	0.006

Note: This table shows the parameter values in the DSGE models. Note that we assume that the persistent of the permanent labour supply shocks is $\rho_b = \rho_a = \rho$ and the long-run average growth rate of labour supply shocks $\mu_b = \mu_a = \mu$.

The labour share α is calibrated to match the capital share data. We hence set α in production to 0.68, which is a standard value for the long run labour share income so that the value of capital share is set to 0.33 to match the average fraction of total income going to capital in emerging countries. The discount factor β is calibrated to match the steady-state capital-output ratio in the capital Euler equation to that in data. The value of β used in the literature ranges from 0.92 to 0.99 for annual frequency for emerging countries. We set β to 0.95, in order to imply a steady-state real interest rate at about 5% per year, which is a value compatible with the observed interest rate face by emerging countries.[21] We set the inverse of the Frisch elasticity of the labour supply ψ of the utility function to 0.33 so that it matches the steady state labour input level in the labour first order condition to that in the data which is commonly used in the RBC literature. The value of the depreciation rate δ ranges from 0.03 to 0.12 per year for emerging countries in the literature. We have used a 7% annual depreciation rate to

[21]However, Garcia-Cicco, Pancrazi, and Uribe (2010) set the parameter β to 0.92, which implies a relatively high average real interest rate of about 8.5 percent annually. They also explained that this value is empirically plausible for emerging market like Argentina.

match the capital law of motion as it falls in the middle of that range.[22] The standard deviation of the technology shocks, σ_a, and the labour supply shocks, σ_b, are calibrated to 1.2% and 0.6%, respectively as in Chang, Doh, and Schorfheide (2006) who estimate a DSGE model with non-stationary hours using Bayesian techniques.[23]

2.6 Results

To evaluate the DSGE model, we resort to the Indirect Inference approach. Accordingly, we estimate a DSVAR model on simulated data from the DSGE model and compute the impulse responses of hours and GDP to technology and labour supply shocks using long-run restrictions. The accumulated IRFs are then compared to those obtained from actual data in EMEs using annual data for the period 1970-2013, as well as their 95% confidence intervals. Recall that, the only identifying assumption imposed in the DSVAR is that labour supply shocks have a permanent effect on hours worked yet technology shocks do not have long-run effects on hours. It also supports the long run restrictions imposed in the DSGE model. These LS shocks can be an important source of fluctuations as we observe persistent fluctuations in labour supply following changes in labour market participation or changes in the demographic structure in EMEs. In addition, we consider larger VAR specifications for the robustness of our first results as well as different shock process for the DSGE models. The standard error bands are computed using a bootstrap procedure with 1000 replications.

2.6.1 Impulse Responses - The Actual Data

We first present the results based on a simple bivariate VAR model with two lags. The accumulated IRFs of hours and GDP after a labour supply shock and a technology shock are reported in Figure 2.3 for each county. Several salient features emerge from our DSVAR: 1) It shows that both a technology shock and a labour supply shock lead to an immediate and permanent rise in real GDP for all the emerging countries, though not statistically significant in the long run. It rises during 2-3 periods, and the response remains positive for each horizon. Only in Sri Lanka, following a LS shock, real GDP increases on impact but decreases after one period and then the response remains negative. 2) In response to the technology shocks, hours worked decline temporarily in Brazil, Hungary and Turkey. It increases in Chile, Mexico, Peru, Sri Lanka, and Thailand but eventually the effect of the technology shocks on hours disappears over time (by assumption). For Colombia and South Africa, technology shocks have a negative impact initially but then return a positive effect on hours worked insignificantly. 3)

[22] Li (2011) have set the depreciation rate to 3% while Garcia-Cicco, Pancrazi, and Uribe (2010) have set this value to 12% for annual frequency in emerging economies.

[23] Also, Dupaigne, Fève, and Matheron (2007) find that the estimated value of the standard deviation of the technology and preference shocks is equal to 1.33% and 0.76%, respectively.

The impact of the (identified) permanent LS shocks on hours worked are positive. It increases for about one year, and eventually reaches a new steady state higher than its pre-shock level.

In the data, we clearly observe that hours worked per capita are highly persistent and non-stationary during the past four decades in EMEs. Hours could be non-stationary because there might be a labour supply shock in these economies. These labour supply shocks could be associated with very dramatic changes in demographic structure, in home and market production, and in labour market participation, especially in female labour participation in these economies. Depending on the frequency, duration and intensity, these dramatic changes can be considered as permanent labour supply shocks. Transient LS shocks can be defined as a temporary exposure to the labour market in EMEs such as migration, births and deaths. However, again, it depends on the frequency, duration and intensity of the shocks. In addition, any shock that affects the composition of factors of production or their relative productivity in the long run will have a long-run effect on real GDP such as changes in technology or changes in government regulation while the temporary rise in government purchases or adverse weather can change real GDP temporarily.

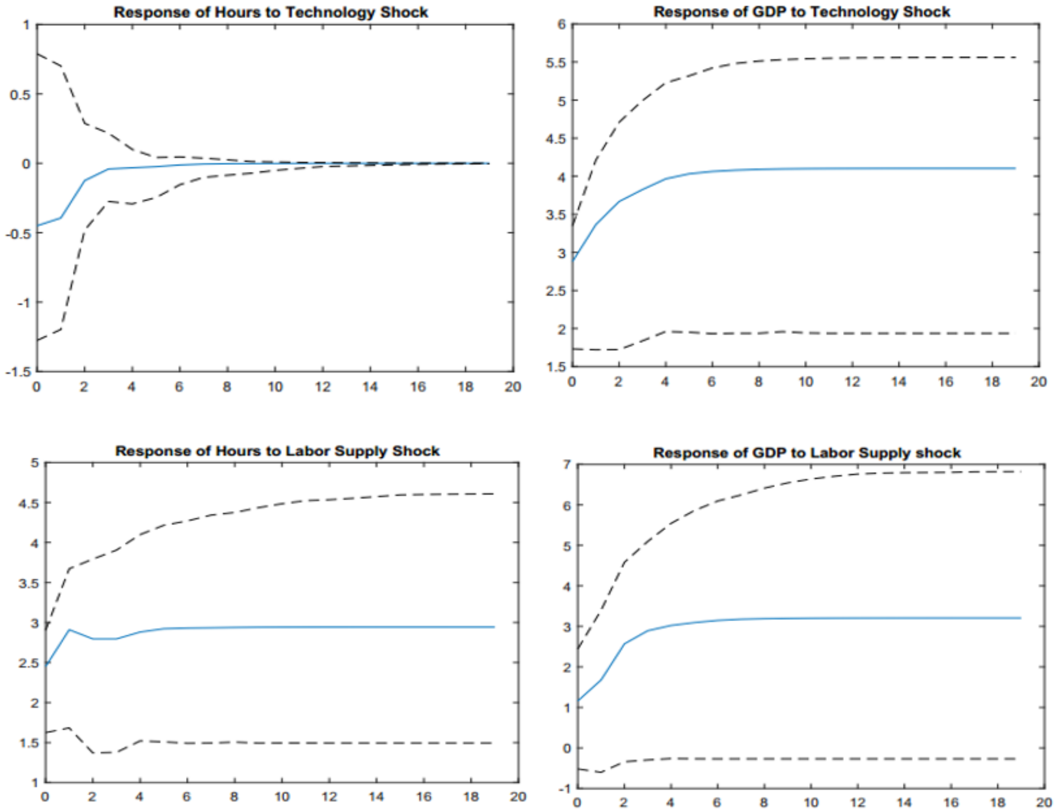
Our empirical framework includes two driving forces which are LS and technology shocks. However, Blanchard and Quah (1989) point out that ignoring some relevant shocks may lead to a significant distortion in the estimated impulse responses. Therefore, Gali (1999) and Francis and Ramey (2005a) address this issue by estimating a five-variable VAR.[24] Moreover, Chari, Kehoe, and McGrattan (2008) check how their results change when they add more variables to the SVAR. They find that the SVAR procedure can uncover the model's impulse response to shocks with additional variables and shocks. To ensure that the VAR procedure works well, we add an extra control variable, the consumption to output ratio (C/Y) to the VAR to see whether our model is robust. We include it because it improves the identification of the technology shocks and displays less controversy about its stationarity in the literature (Gospodinov (2010)). Moreover, Cochrane (1994) contends that the C/Y ratio is special, because it is stable over long time periods (consumption and output are co-integrated), while consumption is nearly a random walk.[25] They also find that when consumption rather than the C/Y ratio is included into a SVAR with long run restrictions, the identification of the responses of hours worked to technology shocks can be seriously disturbed.

[24] Gali (1999) includes the series of real balances, interest rates, and inflation and Francis and Ramey (2005a) include wages, consumption, and investment to the VAR.

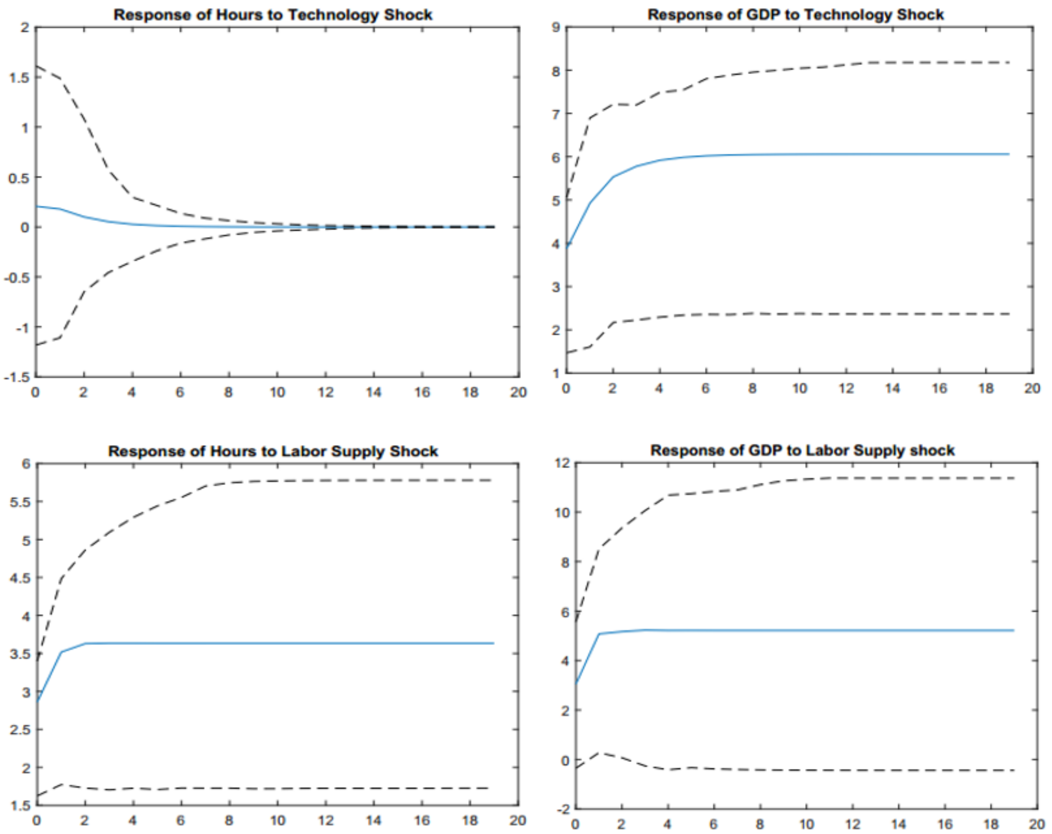
[25] See also Feve and Guay (2009). They use a simple two-step approach to estimate technology shocks from a SVAR model. In the first step, they consider a SVAR model with a set of relevant stationary variables (including the consumption to output ratio and excluding the hours worked series from SVAR) to identify and estimate technology shocks. In the second step, they show how to recover the response of hours to shocks independently of the specification of hours in level or first differences.

Figure 2.3: Impulse Responses From The Actual Data - Two Variables

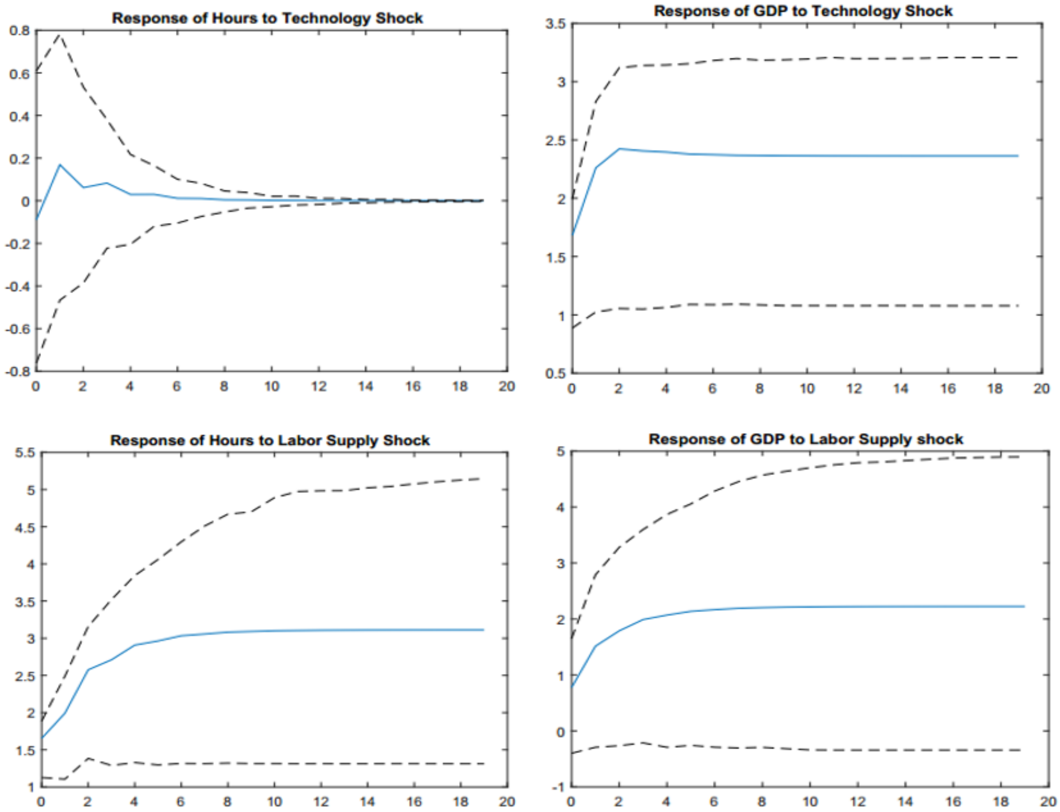
Brazil



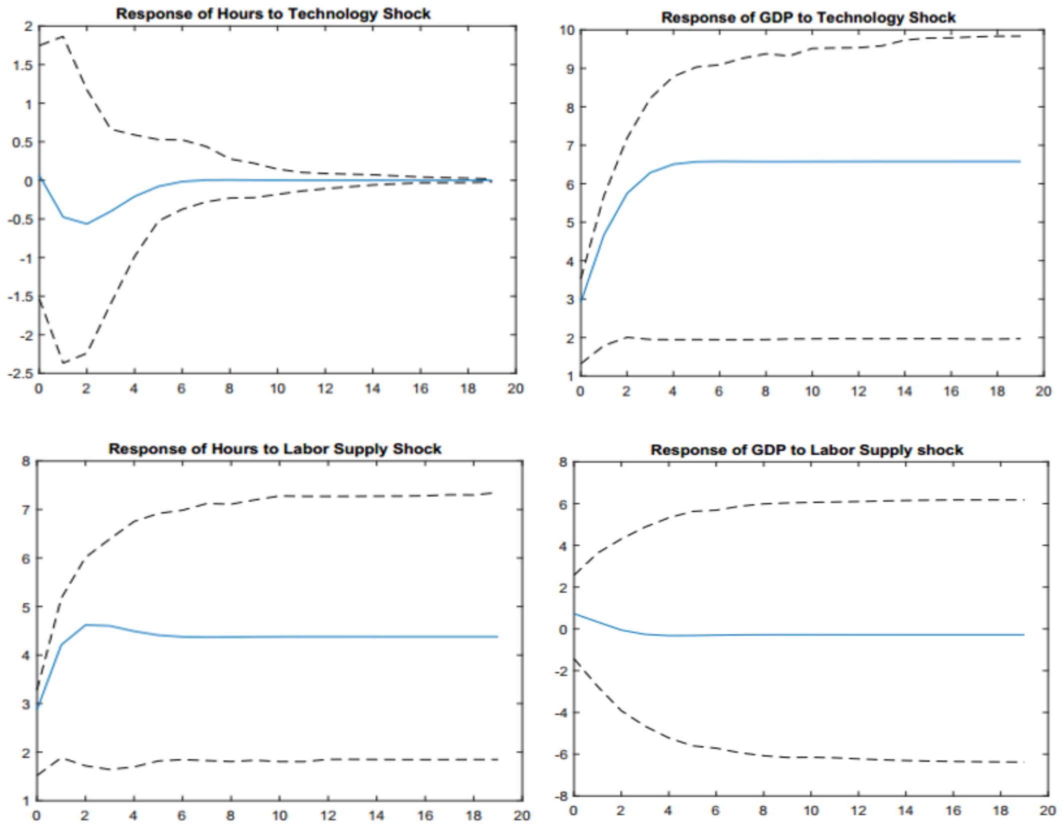
Chile



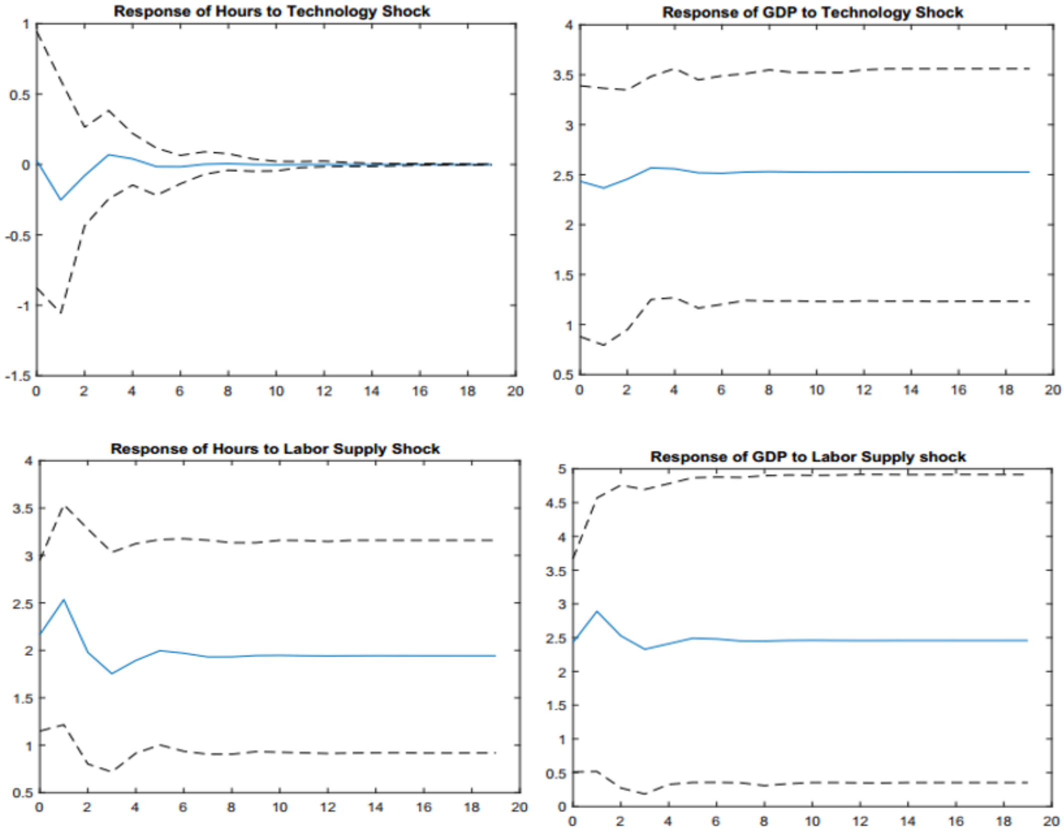
Colombia



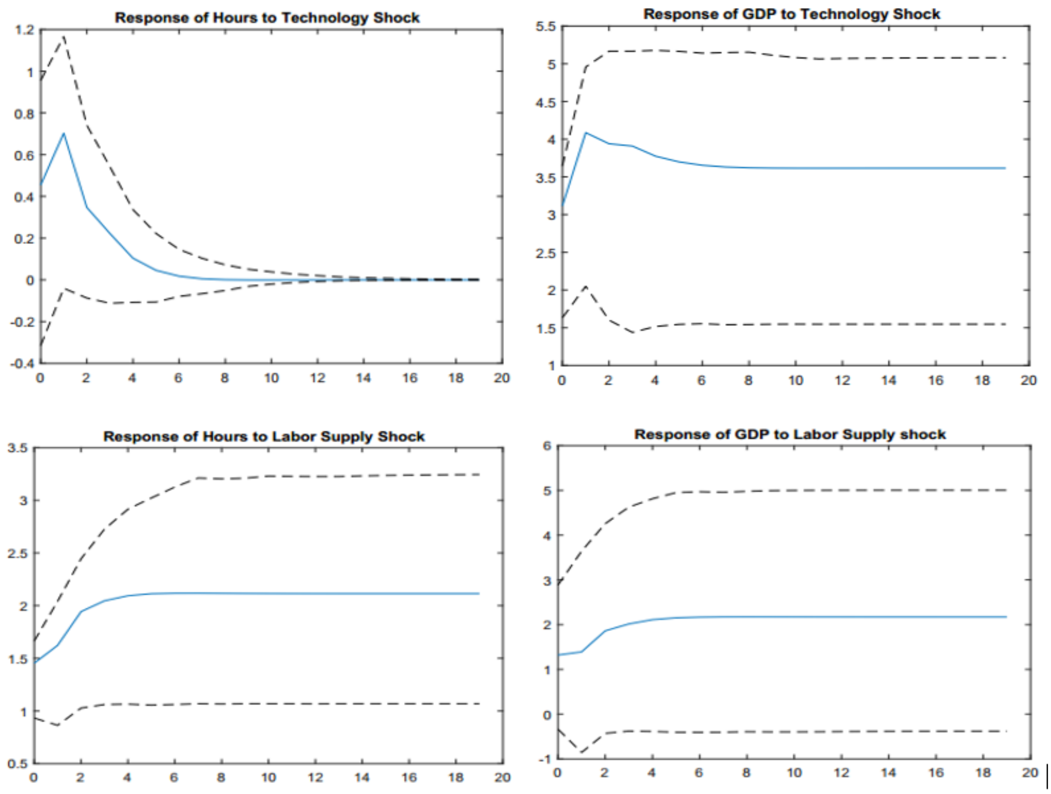
Hungary



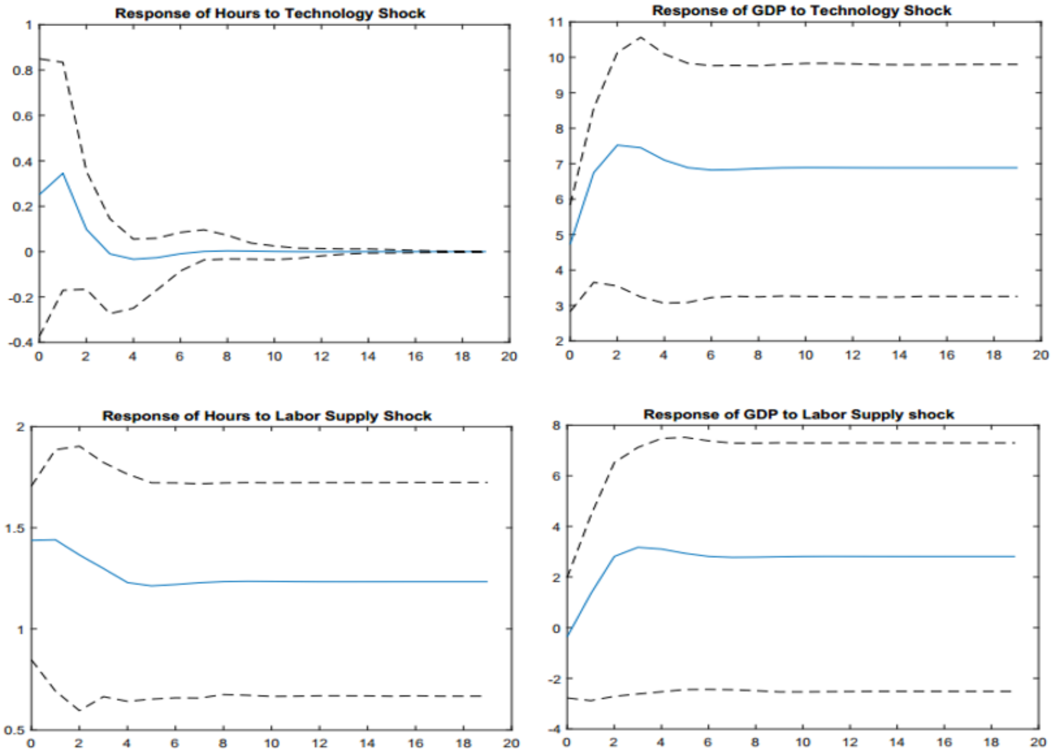
South Korea



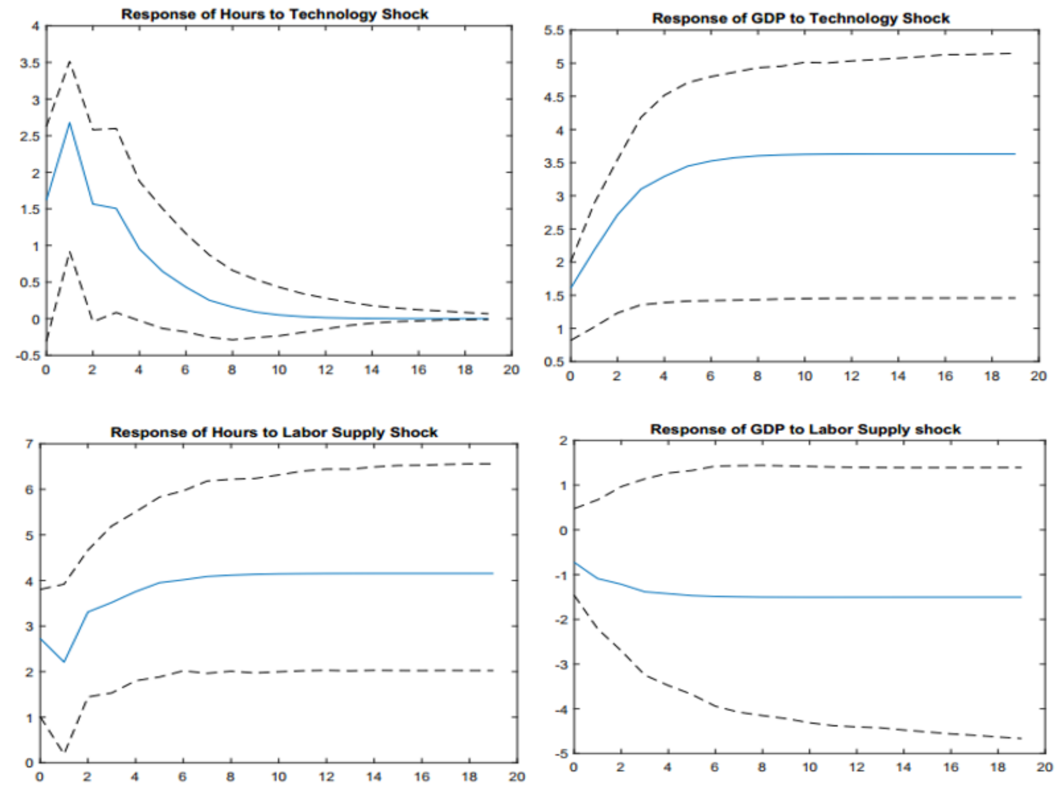
Mexico



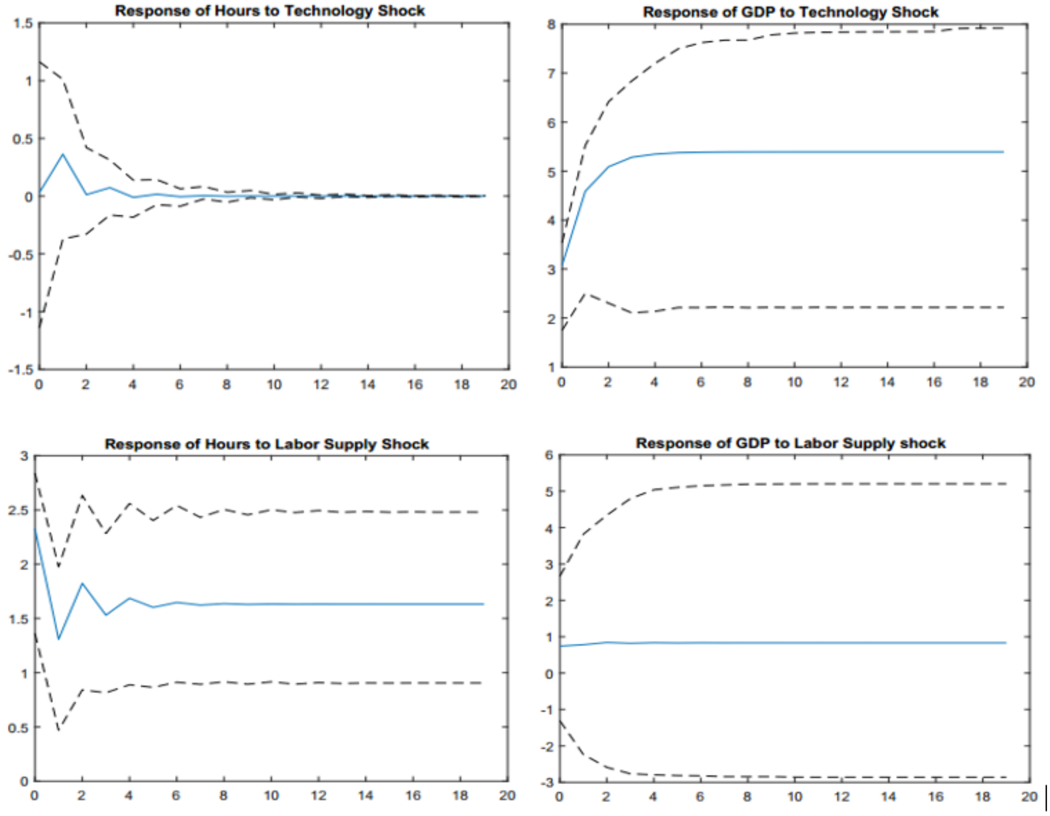
Peru



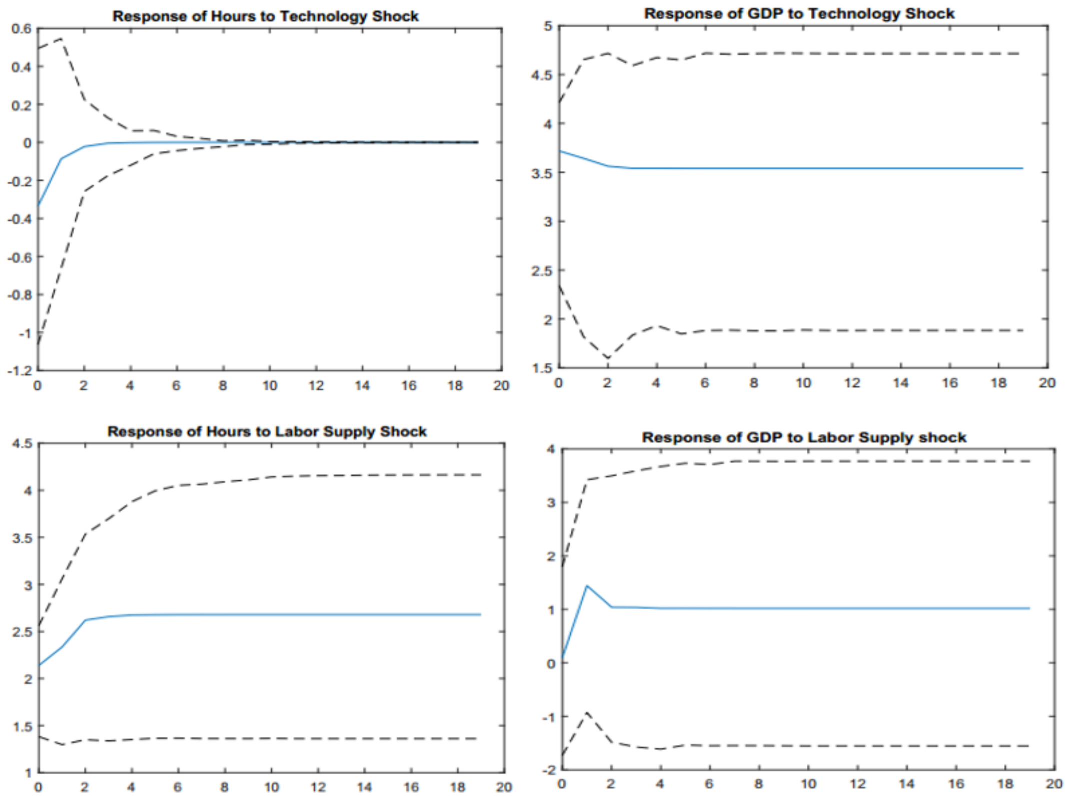
Sri Lanka



Thailand



Turkey



Note: This figure shows the accumulated impulse responses of hours and real GDP to technology and labour supply shocks (blue solid lines) and the 5th and 95th percent confidence bands (black dashed lines) using the two-lag DSVAR procedure with EMEs data set.

The $A(L)$ matrix of this system is a block 3x3 matrix in the lag operator and we specify the three-variable model as follows:

$$\begin{bmatrix} \triangle log(h_t) \\ \triangle log(y_t) \\ log(C/Y) \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) \end{bmatrix} \begin{bmatrix} u_t^{LS} \\ u_t^{TS} \\ u_t^{OS} \end{bmatrix}$$

The estimates generated by that higher dimensional model regarding the effects of shocks are very similar to the ones reported above. If the hours worked is the first variable in the system, we identify the labour supply shocks by imposing the restriction that $A^{1j}(1) = 0$ for j= 2,3. This framework shows that two shocks, consisting of technology shocks and other shocks (OS), do not have a permanent effect on hours. Furthermore, LS and technology shocks and not others, have a permanent effect on GDP, that is $A_{23} = 0$. Lastly, none of these shocks will have a permanent effect on C/Y, because we assume that it is stationary in level in our VAR analysis. The pattern of responses of hours and GDP to both shocks is very similar to that obtained in the bivariate model for all countries. Although adding the consumption to output ratio into the VAR does not modify the previous results in most cases but we definitely obtain more pronounced results compared to the two variable VAR model. As sample countries, the results for Chile and Mexico for a higher dimensional SVAR model are presented in Appendix 2.C.[26]

2.6.2 Impulse Responses - The Simulated Data

We generate 1000 data samples for hours worked and real GDP from the DSGE model. Every data sample consists of 44 annual observations and corresponds to the typical sample size of empirical studies. That is, in order to reduce the effect of initial conditions, the simulated samples include 956 initial points which are subsequently discarded in the estimation. For every data sample, we estimate VAR models with two lags. Before applying VAR procedure, we consider the unit root tests by conducting an ADF and a KPSS tests on simulated series. We find that the test does not reject a unit root and can reject the hypothesis of stationarity in hours worked, respectively.

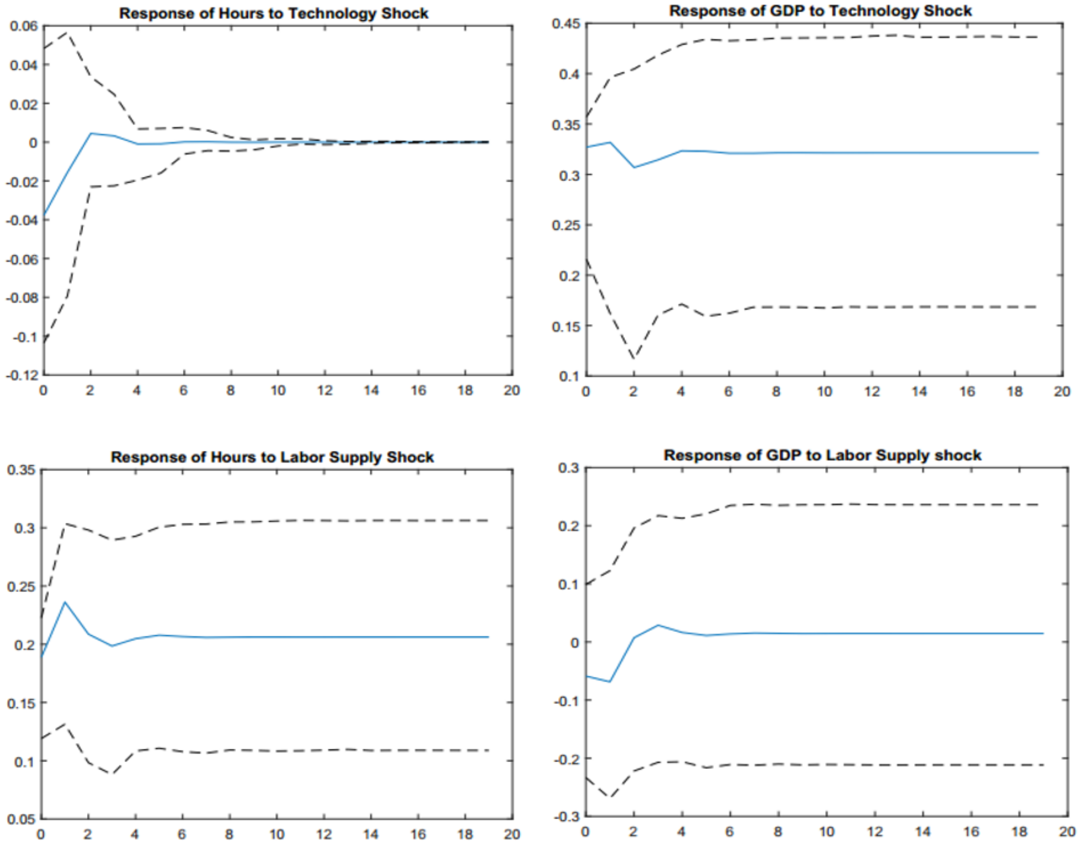
In our benchmark model, we assume that both shocks evolve according to the random walk. Figure 2.4 shows the IRs of hours and GDP to LS and technology shocks from the estimated DSVAR on the artificial data. We observe that hours rise permanently after a positive LS shock but it does so only rises for one period. The dynamic response of technology shocks on hours is negative and these shocks do not have any long run effect

[26]For robustness, we also check IRFs estimated using lags selected by the lag-length tests suggested. We observe slightly more significant results if we estimate our DSVAR model for Chile, Peru, and Thailand (with one lag) and Hungary, Sri Lanka and Turkey (with three lags).

on hours. Also, GDP increases permanently after a positive technology shock. Following LS shocks, real GDP decreases in the beginning of the period but then increases permanently. We observe that the DSVAR is not able to capture the significant impulse responses of this model.

FIGURE 2.4: Impulse Responses From The Simulated Data

Model 1



Note: This figure shows the accumulated impulse responses of hours and real GDP to technology and labour supply shocks (blue solid lines) and the 5th and 95th percent confidence bands (black dashed lines) using the two-lag DSVAR procedure with the simulated data set. In this model we assume that the log production (permanent) technology A_t and labour supply shocks B_t evolve according to a random walk.

For robustness, we first build a DSGE model by following the same procedure as above with the shocks to trend growth of productivity and hence, the permanent labour-augmenting productivity shock, A_t, is non-stationary and represents the cumulative product of growth shocks. It is given by:

$$A_t = a_t A_{t-1} = \prod_{s=0}^{t} a_s,$$

$$\ln(a_t) = (1-\rho_a)log(\mu_a) + \rho_a ln(a_{t-1}) + \varepsilon_t^a.$$

We then build a DSGE model with both a productivity shock and a labour supply shock as a rate of growth shock again following the same procedure described above. That is, the permanent labour supply shock, B_t, is non-stationary and represents the cumulative product of growth shocks b_t:

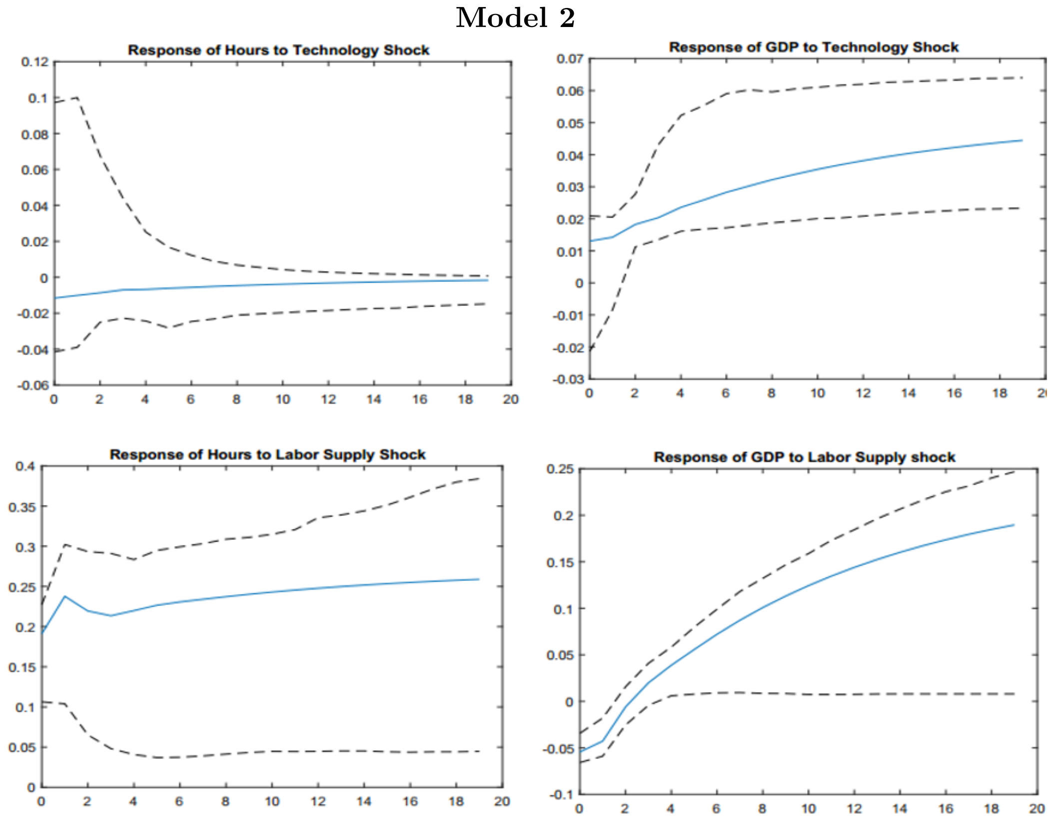
$$B_t = b_t B_{t-1} = \prod_{s=0}^{t} b_s,$$

$$\ln(b_t) = (1-\rho_b)log(\mu_b) + \rho_b In(b_{t-1}) + \varepsilon_t^b.$$

In these models, the parameter a_t and b_t represent the rate of growth of the permanent technology shock and labour supply shock, respectively. $|\rho_a| < 1$ and $|\rho_b| < 1$ are the persistence parameter of the process a_t and b_t, respectively. ε_t^a and ε_t^b represent iid drawn from a normal distribution with a zero mean and standard deviation σ_a and σ_b, respectively. μ_a and μ_b are the long run average growth rate of both shocks. The persistence of the permanent technology shocks ρ_a and the long-run average growth rate of technology shocks μ_a are set to 0.01 and to log (1.0066), respectively as in Aguiar and Gopinath (2007). Note that we assume that the persistence of the permanent labour supply shocks ρ_b and the long-run average growth rate of labour supply shocks μ_b are equal to the ones in that of permanent technology shocks. We make this assumption based on the observation we made in the literature and we could not find any value for them in the literature. Chang, Doh, and Schorfheide (2006) estimate the persistence of the temporary labour supply shocks in the stationary model and find that it is equal to 0.95, which is also equal to the value for the persistence of the temporary productivity technology shocks as in Aguiar and Gopinath (2007). Hence, we assume that ρ_a and μ_a can be equal to ρ_b and μ_b, respectively (see Table 2.2).

We observe that the pattern of the IRFs does not change much but it seems that the VAR model is better at capturing the dynamic response of LS and technology shocks on hours worked and real GDP in Model 2 and 3 (see Figure 2.5 and 2.6) compared to the results from the benchmark model. Moreover, the response of GDP to technology shocks

FIGURE 2.5: Impulse Responses From The Simulated Data



Note: This figure shows the accumulated impulse responses of hours and real GDP to technology and labour supply shocks (blue solid lines) and the 5th and 95th percent confidence bands (black dashed lines) using the two-lag DSVAR procedure with the simulated data set. In this model we assume that there are the shocks to trend growth of productivity.

and labour supply shocks is only different in Model 3 compared to the benchmark and second model. The effect of technology shocks on GDP is initially negative and then returns to positive in the long-run and LS shocks have a positive permanent impact on real GDP in this model.

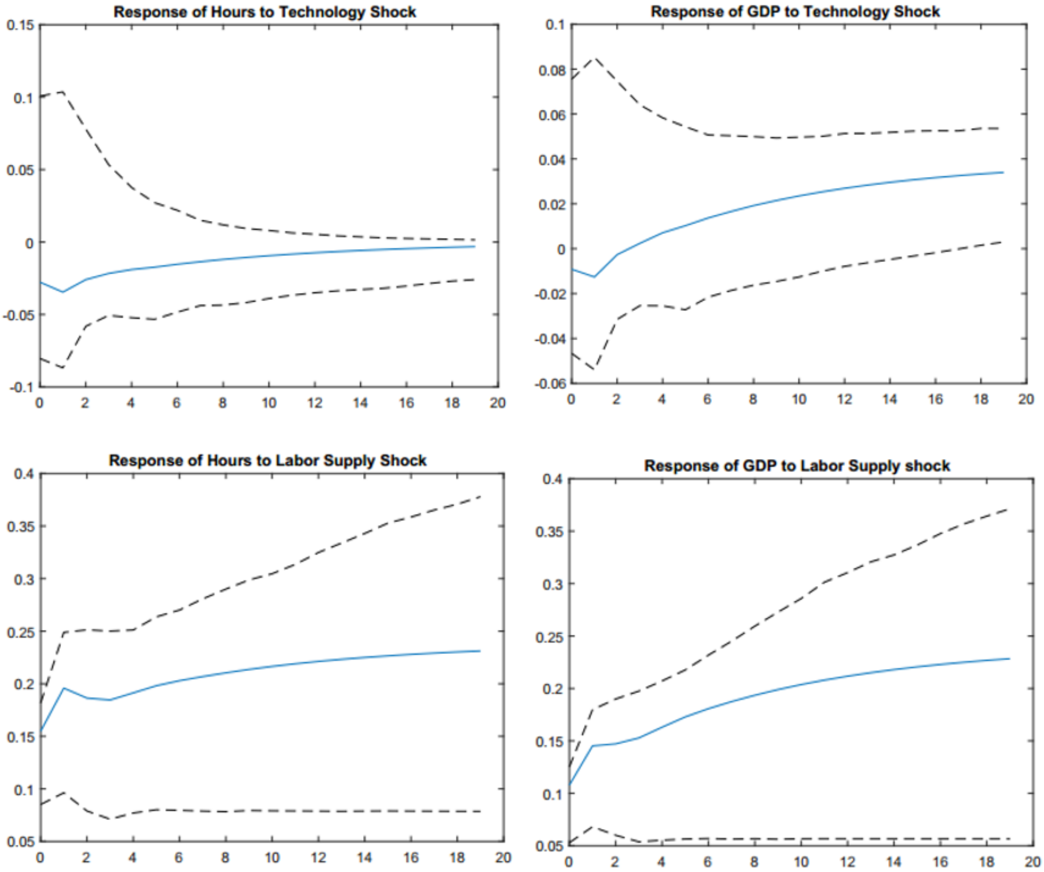
Our results show that the changes in the structure of labour markets in these economies can account for permanent shifts in hours worked especially the changes in female labour force participation as LS shocks have a positive and permanent effect on hours worked while the expected future real wage might lead to negative and temporary impact on hours worked. In addition, the temporary rise in government purchases increases real GDP temporarily while the changes in technology increase real GDP permanently.

2.6.3 Comparison of Impulse Responses

These results allow us to compare empirical impulse responses based on the actual data to impulse responses from DSVARs run on the simulated data from the models. There are four main conclusions that can be drawn. Firstly, it seems that the response

Figure 2.6: Impulse Responses From The Simulated Data

Model 3



Note: This figure shows the accumulated impulse responses of hours and real GDP to technology and labour supply shocks (blue solid lines) and the 5th and 95th percent confidence bands (black dashed lines) using the two-lag DSVAR procedure with the simulated data set. In this model we assume that both productivity and labour supply shocks act as a rate of growth shock.

of hours to technology shocks are consistent in the data and in the model for Brazil, Hungary and Turkey where following a technology shock, hours decrease. Secondly, our models can produce the impulse response of hours after labour supply shocks for all emerging economies where these shocks increase hours worked permanently in the long-run. Moreover, Model 2 and 3 are better able to capture the response of hours worked to LS shocks compare to the benchmark model. Thirdly, in our benchmark and second model we find that the response of GDP to technology shocks is positive in the long-run which imitates the pattern of IRFs from the DSVAR for all EMEs. In Model 3, real GDP also increases permanently but initial effect of a positive technology shocks is negative. Lastly, in the model with both a productivity shock and a labour supply shock as a rate of growth shock, we find that real GDP rises permanently after a LS shock. We observe that this model can produce similar patterns to those in EMEs (except in Sri Lanka).

In our study, we use the Indirect approach which is applying the same treatment to actual data and data from the model but most of the existing SVAR literature compare directly impulse responses from SVARs on the data to theoretical impulse responses from the model. Then, a natural question emerges: What would happen if we test a DSGE model by comparing directly its theoretical IRFs with those from the DSVAR? We observe that following a positive technology shock, hours worked increase and return to its steady-state implying that permanent changes in the technology shock do not have permanent effects (see Appendix 2.C). Following a positive labour supply shock, hours worked rise permanently in the long-run. Moreover, technology shocks have a negative long-run effect on real GDP. The response of GDP to LS shock decreases initially but then increases permanently in the benchmark and second model. It rises in the long run in Model 3. In addition, we observe that the response of the labor supply shocks to GDP in the benchmark model and in the second model are the same where the response of GDP to labor supply shock first falls and then increases in the long run. However, when we apply DSVAR approach to the simulated data from these models, the pattern of the IRFs are the same but our VAR is much better capturing the response of real GDP LS shocks in Model 2.

Lastly, we try to figure out why the results do not appear to be significant. First, the reason might be that we use annual data. Hence, we treat the simulated data as quarterly in the DSGE model and then apply DSVAR with four lags. Second, maybe we do not obtain sufficient data from the models. To address this issue, we simulate 1200 observations from the model; then we estimate a VAR for 1000 observations with two lags and compute impulse responses. We see that the VAR is still not able to capture the significant impulse responses. As already stated in Chari, Kehoe, and McGrattan (2008)'s study "the small number of lags in the estimated VAR dictated by available data lengths makes estimated VAR a poor approximation to the infinite-order VAR of the observables from the model, that is the VAR suffers from lag-truncation bias". The issue is that we cannot estimate the VAR with infinite lags because of dimensionality problem, so we have to choose the lag order in the VAR.

The overall results show that our models are able to indirectly mimic IRFs obtained from a DSVAR on the actual data although our DSVAR specification poorly identifies the impulse responses of hours worked and real GDP to both shocks. We can conclude that a DSGE model with permanent LS shocks that can generate a unit root in hours worked have a better time series fit for EMEs and matches with the empirical findings. Therefore, a model with LS shocks is required to properly evaluate the DSVAR in EMEs as the data support this view. In addition, these shocks can be the driving force behind business cycle fluctuations in EMEs as they can explain the movements in hours worked.

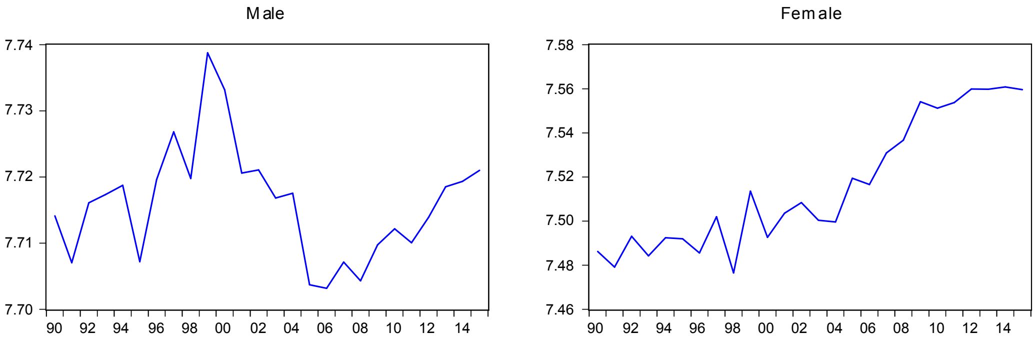
2.7 Conclusion

In this paper, we test a DSGE model using Indirect Inference on impulse responses of hours worked and real GDP after technology and non-technology shocks in EMEs. We observe that the behaviour of hours worked is non-stationary between 1970-2013 in these economies but many dynamic macroeconomic models assume that hours worked are stationary. Based on these observations, we provide empirical evidence on the impact of technology and non-technology shocks on hours and GDP using DSVAR model. As a data generating process, we then illustrate that DSGE models can be easily modified to incorporate non-stationary labour supply shocks which generate permanent shifts in hours worked. This model satisfies completely the identifying assumption of the DSVAR specification which is only LS shocks can have a long-run impact on hours worked. We then compare the responses of hours and GDP in DSVAR model obtained using data generated by the estimated theoretical model to those obtained using actual data. Our main findings are that 1) hours increase permanently after a positive labour supply shock in these economies and 2) LS shocks can be the main driving force behind business cycle fluctuations in EMEs, which are able to replicate the impulse responses of the DSVAR if the model and actual data are treated symmetrically.

In this study, we emphasize that the changes in the structure of labour markets in these economies can account for permanent shifts in hours worked especially the changes in female labour force participation. Therefore, more work must be undertaken to understand economic factors behind the fluctuations in hours worked without violating the balanced growth hypothesis, so that a model with household's labour force participation may be worthwhile exercise as well as focusing on more sophisticated DSGE models with real and nominal frictions for future research.

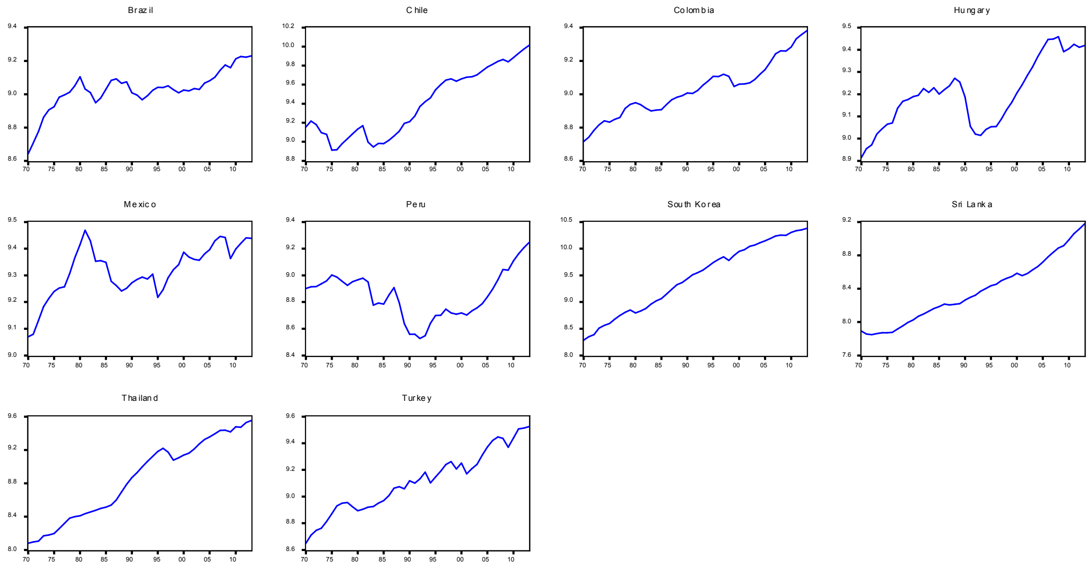
2.A Appendix: Figures

Figure 2.7: The Fluctuations of Intensive Margin by Gender in Mexico



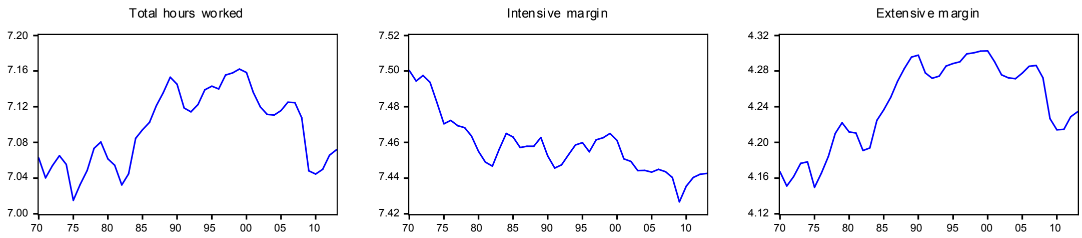
Note: This figure shows the fluctuations of intensive margin by gender in Mexico from 1990 to 2015. The data is logged.

Figure 2.8: The Fluctuations of Real GDP



Note: This figure shows the fluctuations of real GDP in EMEs. The data on GDP is total GDP, in millions of 1990 US dollars from 1970 to 2013 and is logged.

Figure 2.9: The Fluctuations of Hours in US



Note: This figure shows the fluctuations of total hours worked, intensive and extensive margins in the USA for the period 1970-2013.

2.B Appendix: The First Order Conditions of the Model and Steady States- Benchmark Model

The first-order conditions of consumption, hours and capital respectively are given by:

$$\lambda_t = C_t^{-1}, \tag{2.B.1}$$

$$H_t^{1/\psi} B_t^{-(1+1/\psi)} = C_t^{-1} W_t,$$

$$\lambda_t = \beta \lambda_{t+1}(1 + R_{t+1} - \delta).$$

Since all the variables are stationary (see model section), we can compute a steady state, dropping time subscripts. Then, the solution for the steady state of the model is as follows.

The rental rate of capital:

$$R = \frac{1}{\beta} - (1 - \delta), \tag{2.B.2}$$

The output to capital ratio is derived from the marginal product of capital and R which are equal to each other:

$$\frac{Y}{K} = \frac{R}{(1-\alpha)},$$

The investment to output ratio is derived from capital equation:

$$\frac{I}{Y} = \frac{1}{Y/K}\delta,$$

The consumption to output ratio is obtained from the budget constraint:

$$\frac{C}{Y} = 1 - \frac{I}{Y},$$

Hours can be derived from the marginal rate of substitution between leisure and consumption equation:

$$H = \alpha(\frac{1}{C/Y})^{\psi/(1+\psi)},$$

Capital is derived from the rental rate of capital equation:

$$K = (\frac{H^\alpha}{Y/K})^{1/\alpha},$$

Output is derived from the Cobb-Douglas production equation :

$$Y = K^{1-\alpha} H^{\alpha},$$

Consumption is from the consumption to output ratio and output:

$$C = \frac{C}{Y}\, Y,$$

Investment is obtained from the investment to output ratio and output:

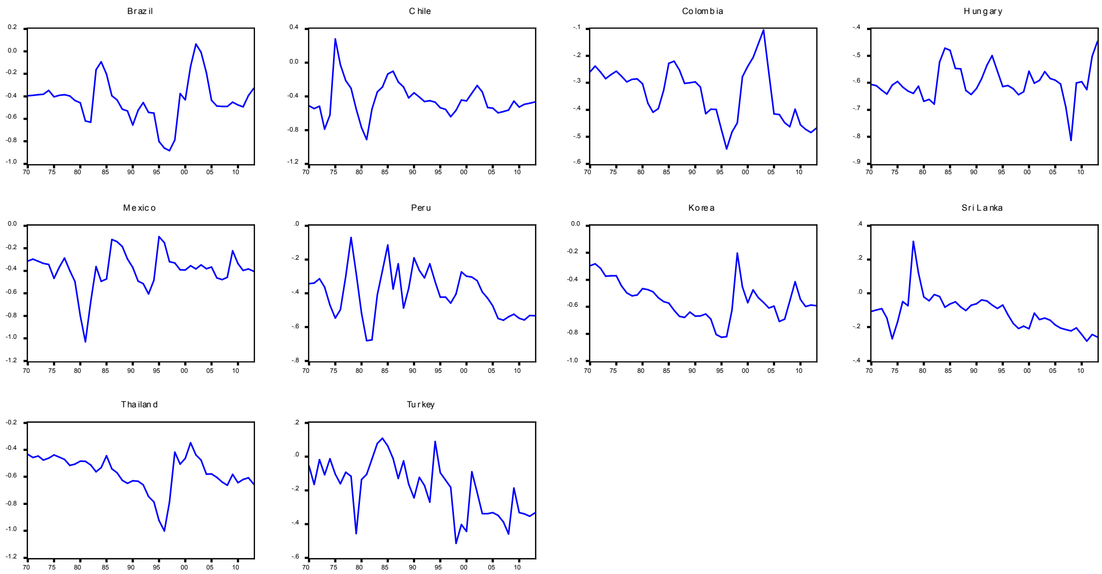
$$I = \frac{I}{Y} Y,$$

Wages:

$$W = \alpha\, \frac{Y}{H}.$$

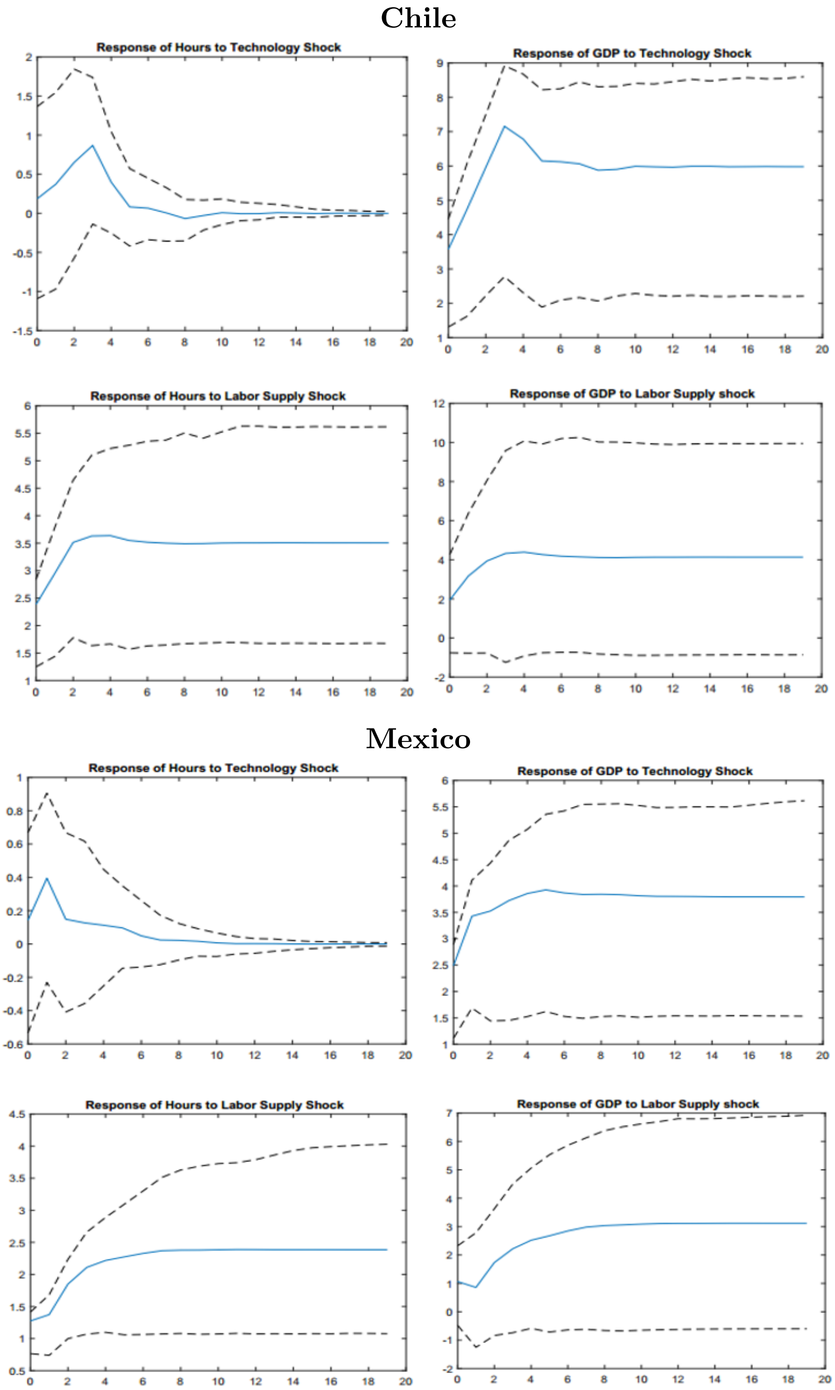
2.C Appendix: Additional Impulse Responses

FIGURE 2.10: The Behaviour Consumption to Output Ratio



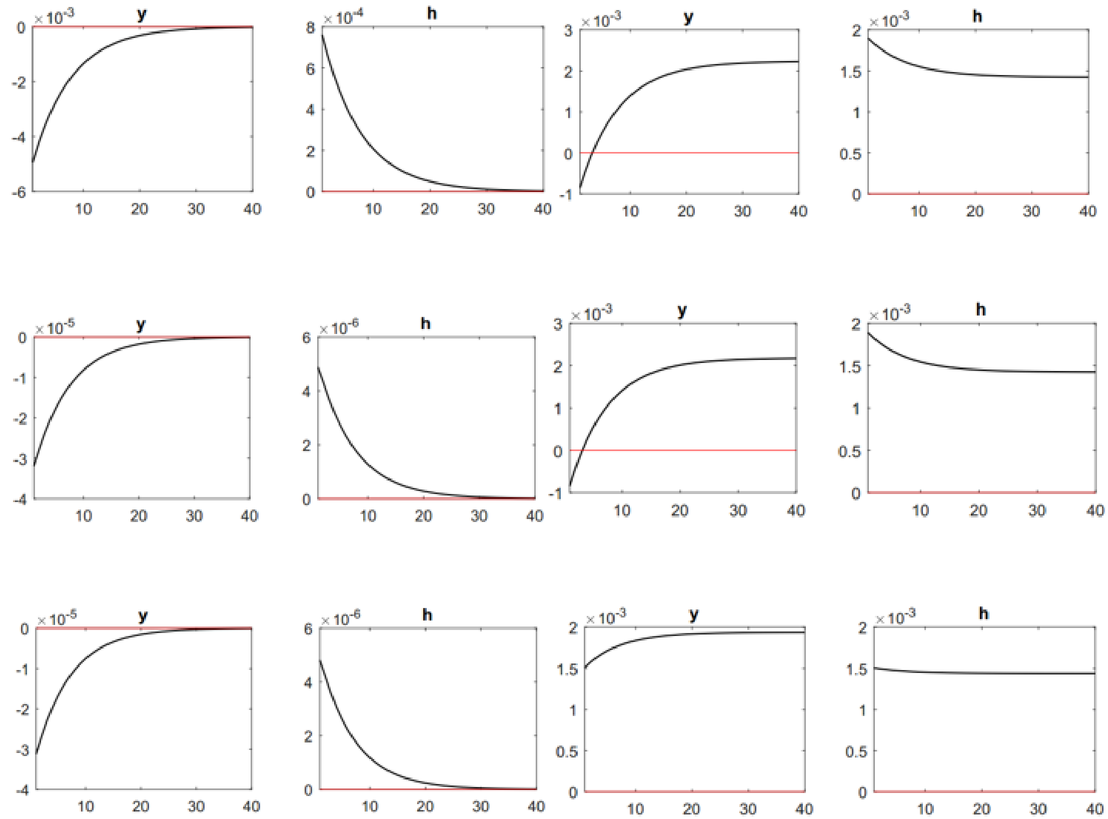
Note: This figure displays the behaviour of the consumption to output ratio in EMEs from 1970 and 2013. Household consumption expenditure data are used at current prices in US dollars, including non-profit institutions serving households and the data on GDP is total GDP, in millions of current US dollars. The data is logged.

Figure 2.11: Impulse Responses From The Actual Data - Three Variables



Note: This figure shows the accumulated impulse responses of hours and real GDP to technology and labour supply shocks (blue solid lines) when we include consumption to output ratio in our estimation and the 5th and 95th percent confidence bands (black dashed lines) using the two-lag DSVAR procedure with Chile and Mexico as sample countries.

Figure 2.12: Impulse Responses From The Models



Note: This figure shows the impulse responses of real GDP and hours worked to technology and then the responses to labour supply shocks in our models. In first model we assume that the log production (permanent) technology A_t and labour supply shocks B_t evolve according to a random walk (first row). In the second model, we assume that there are the shocks to trend growth of productivity and in the last model (second row) we assume that both productivity and labour supply shocks as a rate of growth shock (last row). First and third columns show the impulse responses of output to technology and LS shocks, respectively. Second and fourth columns show the impulse responses of hours worked to technology and LS shocks, respectively.

Chapter 3

Informal Employment and Business Cycles in Emerging Market Economies

3.1 Introduction

Business cycles in emerging and developed countries have different characteristics. Specifically, the data used in this study for emerging market economies (EMEs) shows that the relative volatility of consumption to output is approximately 1.20, while in developed countries it is around 0.76. In addition, emerging countries display higher volatility of output and a counter-cyclical trade balance share. Another difference between developed and EMEs business cycles is the behaviour of employment. In contrast to developed economies, EMEs have a lower cyclicality of total employment. In the emerging market business cycles literature, many researchers focus on the sources of business cycles in these economies using dynamic general equilibrium (DSGE) models and discuss how frictions matter for the propagation of technology or interest rate shocks.[1] However, they mostly ignore labour market frictions.[2] Even less attention has been given to informal employment, despite the existence of a large informal labour market in these economies. The size of informal employment varies widely depending on the country and the measure used, but our data reveals that informal employment is between 20% and 80% of the total labour force in these economies.[3] Some of the differences between

[1] For example, Aguiar and Gopinath (2007) consider different stochastic processes of TFP and Neumeyer and Perri (2005) relate interest rate fluctuations in international financial markets to the business cycle of emerging markets. See also Garcia-Cicco, Pancrazi, and Uribe (2010) and Chang and Fernandez (2013)'s work. They show that the business cycle in EMEs is driven by external shocks to the country's interest rate premium in conjunction with financial frictions.

[2] There are notable exceptions introducing labour market frictions in small open economies such as Boz, Durdu, and Li (2009b), Boz, Durdu, and Li (2012) and Li (2011)'s works.

[3] Schneider (2004) estimates that informal employment constitutes between 40% and 80% of the total labour force in these economies. Enste and Schneider (2000) discuss that it likely that its share in the

emerging and developed economies over the cycle might be linked to the large informal labour market in EMEs.

This paper is motivated by these observations and has two objectives. The first objective is to systematically document the relationship between informal employment and business cycles in EMEs and to understand how informal employment is relevant in shaping the aggregate dynamics. The second objective is to lay out a small open economy model with both formal and informal labour markets as in Fernandez and Meza (2015) to account for the empirical findings. As there is lack of appropriate data for these economies, the first contribution of the paper is to construct and analyse several alternative time series of informal employment at a quarterly frequency for Mexico, Colombia, South Africa, and Turkey, as representative of emerging economies.[4] Given the various types of informal employment, one should not expect all of them to respond in the same way to business cycles. Moreover, some empirical evidence shows that informal employment acts as a buffer for fluctuations in formal employment, increasing flexibility in the labour market and consequently affecting the transmission mechanisms of shocks to the economy (see Castillo and Montoro (2010)'s work).[5] However, we observe that employment protection is high and different among these economies. For instance, severance pay for redundancy dismissal (in salary week) is 22.0 (in Mexico), 23.1 (in Turkey), 16.7 (in Colombia) and 5.3 (in South Africa).[6] The second contribution of the paper is hence to explore the effects of changes in the degree of employment protection on the informal employment and the business cycles in EMEs and which extent the informal sector acts as a buffer in the face of adverse shocks to the labour market.

There are few papers that explicitly model informality in a DSGE framework even though the idea of working on the informal sector is not new. Conesa, Diaz-Moreno, and Galdon-Sanchez (2002) show that there is a negative relationship between the ratio of employment to population and the standard deviation of GDP. Therefore, they build a model where labour is assumed to be indivisible in the formal sector, whereas it is divisible in the informal sector. Fiess, Fugazza, and Maloney (2010) focus on accounting for the cyclical behaviour of informal self-employment. For that, they present a small

labour market is non-trivial. Moreover, Schneider (2004) reports the size of the informal economy in developing countries is somewhere between 25% and 76% of GDP, while for developed countries it is between 6% and 18%.

[4]Note that Fernandez and Meza (2015) already presented some of the measures we used for Mexico.

[5]Carillo and Pugno (2004) reports a cyclical pattern for informal employment in a set of emerging economies. In addition, Galli and Kucera (2003), Loayza and Rigolini (2006) and Bosch and Maloney (2010) find that informal employment is countercyclical and acts as a buffer during the economic recession.

[6]See the Doing Business Indicators (2017) in Table 3.6 as a measure of the monetary costs regarding weeks of severance payments due for firing a worker, averaged across workers of 1, 5, and 10 years of tenure. Moreover, see Lama and Urrutia (2011) who present business cycle properties and employment protection in EMEs and developed economies.

open economy model where a salaried sector produces a tradable good while the self-employed sector produces a non-tradable good. Restrepo-Echavarria (2014) examines how the relative volatility of consumption to GDP is affected by the presence of a shadow economy and quantifies it in a two-sector DSGE model with formal and informal consumption goods. She finds that including the informal economy accounts for relative volatility of consumption. Solis-Garcia and Xie (2017) build a model that includes an informal economy and distinguish between measured (formal) and total (informal and formal) output to account for the differences in the volatility of measured real GDP per capita between developing and developed countries. From the New Keynesian framework, Castillo and Montoro (2010) use a model with frictions in the labour market by introducing formal and informal labour contracts and analyse the interaction between the two sectors and monetary policy. They find that informal economy generates buffer effect that diminishes the pressure of demand shocks on aggregate wages and inflation.

We first highlight the differences regarding aggregate employment between EMEs and Canada, as a similar developed counterpart. Relative volatility of employment is higher in Colombia, South Africa and Turkey but lower in Mexico than that of Canada. Furthermore, the correlation of employment with output is substantially lower in these economies compared to Canada. The large informal labour market explains why employment in these economies shows low cyclicality. We then document the facts about the informal employment in EMEs. The results show that the behaviour of informal employment varies depending on the measure and the country. It will be a challenge for us to evaluate the model regarding its performance along the second moments for these economies. Hence, we assume that people are self-employed in the informal sector as it is a good proxy for informality in these economies.[7] Based on this measure, informal employment is countercyclical in Mexico, Colombia, and Turkey but pro-cyclical in South Africa. Besides, it is negatively correlated with formal employment in Mexico but positively correlated in Colombia, South Africa and Turkey. Also, informal employment is more volatile than formal employment in Mexico and South Africa, but it is less than that of Colombia and Turkey. We claim that the differences in the degree of employment protection among countries can explain the differences in data moments between EMEs.

Motivated by these stylized facts, the model in this paper builds on the works of Fernandez and Meza (2015) where there is a small open economy with both formal and informal labour markets. In this model, we assume that households choose how much labour to allocate to each market. As in Aguiar and Gopinath (2007), technology in the formal sector is shocks to the growth rate of labour-augmenting productivity. These shocks in the formal sector are pass-through to the informal sector. More specifically,

[7] In the data section, we show how the behaviour of informal employment varies depending on the different measures of informal employment and the country. Note that we only have one measure for South Africa which is informality in non-agriculture.

the shocks to both markets are imperfectly correlated. It is worth emphasizing that our model shares many of the features of that of Fernandez and Meza (2015) since both models try to understand informal employment over the business cycle. However, their model does not answer our questions properly as they ignore labour market regulations which are high and different among EMEs. We hence introduce labour adjustment costs (LACs) in their model following Fairise and Langot (1994b) and Janko (2008) as employment protection in these economies. We also consider temporary productivity shocks. These shocks are important because if we only include permanent shocks in the model, then the firms must fire the workers as employment protection may be a temporary rigidity.[8] In addition, we estimate the model by minimizing the distance of a set of second moments with respect to the data for each country. We do so for our key parameter values in order to show how the differences in LACs affect the business cycles in these economies as well as the standard deviations of shocks and the pass-through of the shocks. Note that the value of LACs in the estimated model for each country is consistent with the facts about employment protection we presented. This will then allow us to explore which extent the informal sector acts as a buffer for the formal sector for these economies, given that level of protection.

The model is then evaluated regarding its performance along the second moments that describe business cycles in EMEs. In our benchmark model, we assume that both sectors have the same labour adjustment costs as well as the pass-through of both shocks from the formal to the informal sector is the same. The results show that it matches reasonably well with the data. It produces satisfactorily the pro-cyclicality of formal employment in Mexico and the high output volatility in Mexico and South Africa as well as high consumption volatility in Mexico and Turkey. Moreover, in the estimated model, we find that informal employment acts as a buffer as it is countercyclical and formal employment is pro-cyclical for these economies which supports to the findings from the data except for South Africa. Regarding the volatilities, the results are reversed. Informal employment does not act as a buffer as the formal employment is more volatile than the informal employment which contrast with the evidence in the data except for Colombia. We then analyse the sensitivity of our results. We first assume that LACs exist only in the formal sector while all the other parameter values are the same as in the benchmark mod el (Case 1). We also estimate the model by assuming that LACs are not equal to each other between the sectors while the pass-through of both shocks from the formal to the informal sector is the same (Case 2). We find that the costs in the formal sector are larger than in the informal one. We lastly estimate the model by assuming that the pass-through of both shocks from the formal to the informal sector is different as well as LACs are not equal to each other among sectors (Case 3).

[8] Note that Fernandez and Meza (2015) also include this shock in their model as a robustness check but not in this context.

Overall, these alternatives improve the performance of model to account for the positive/negative correlation between formal and informal employment as well as the pro-cyclicality/counter-cyclicality of informal employment in these economies compared to the benchmark model. Our observation is that a country which has lower LACs leads to higher formal employment volatility and lower counter-cyclicality of informal employment as well as lower pro-cyclicality of total employment and formal employment. Hence, the degree of employment protection is important in determining how these variables react when the economy faces shocks as well as the size of the shocks has impact on these facts compared to the LACs. In addition, the size of shocks in our model is lower compared to earlier studies in the literature such as Aguiar and Gopinath (2007). Thereby, the model with informal sector has a powerful propagation mechanism for shocks to replicate the aggregate variables in these economies. Lastly, the value of pass-through of shocks is important; as it falls, volatility in the labour market increases. Our study motivates the empirical research towards the estimation of LACs, the standard deviation of shocks and pass-through of the shocks for EMEs as the behaviour of variables change depending on these parameter values and show whether the informal employment acts or does not act as a buffer in the formal sector. The details are presented in results section.

The rest of this paper is organized as follows. Section 3.2 provides the data and the empirical findings. Section 3.3 presents the model. Section 3.4 presents the calibration. Section 3.5 presents the main results. Finally, we conclude in Section 3.6.

3.2 Data

In this section, we provide the data sources and the stylized facts in EMEs and Canada. These facts will later serve both as guidelines when building and evaluating the model presented in the next section. We use quarterly data for Mexico (2000.Q2-2010.Q4), Colombia (2007.Q1-2017.Q1), South Africa (2008.Q1-2017.Q1) and Turkey (2005.Q1-2017.Q1). Note that we just use quarterly data for macro moments in Canada (2002.Q1-2017.Q2). We observe that we obtain some ambiguous results for the business cycle fluctuations. The reason might be that we are not able to obtain large data set for our sample countries, especially for informal employment data but we believe that we have sufficient annual data for this analysis.

3.2.1 Data Sources

The data for real aggregate GDP, consumption (private final consumption expenditure), investment (gross fixed capital formation), exports and imports for all economies is obtained from OECD database. The data for Mexico is in US dollars, volume estimates, fixed PPPs, OECD reference year and annual levels but it is in national currency, constant prices, national base year, annual levels and seasonally adjusted for other countries. All variables are in per capita terms. Note that the data is de-seasonalized if necessary using Eviews 9.0, census X12, multiplicative method, trend filter X12 default, seasonal filter X12 default. The series are logged first except for the ratio of net export to GDP and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600 (See Hodrick and Prescott (1981)).

The data on aggregate employment and informal employment for Mexico are collected from INEGI.[9] INEGI reported ENOE (Encuesta Nacional de Ocupacion y Empleo) data as the number of people. We have six informality measures in Mexico for 2000.Q2-2010.Q4 : h_1^i (employed in micro business), h_2^i (employed in micro business without fixed establishment), h_3^i (employed in micro business with fixed establishment), h_4^i (employed and remunerated without benefits provided by labor legislation), h_5^i (self-employed) and h_6^i (workers in the informal sector-employment in economic units not distinguished from households). To construct the series for formal employment (h^f), we calculate aggregate employment minus the respective series of informal employment.

For Colombia, the data come from DANE (Departamento Administrativo Nacional de Estadistica). DANE reported Gran Encuesta Integrada de Hogares (GEIH) data as total and informal employment in 13 cities and metropolitan areas.[10] We have two informality measures for informal employment in these cities: h_1^i (employed according to company size up to 5 workers) and h_2^i (self-employment). The data for South Africa are compiled from Statistics South Africa (Stat SA). We have only one informality measure: h_1^i (informality in non-agricultural).[11] Lastly, for Turkey, the data are compiled from Household Labour Force Surveys (HLFS) conducted by the Turkish Statistical Institute (TurkStat). We have three measures of informality:[12] h_1^i (in non-agriculture), h_2^i (self-employment), and h_3^i (employed according to company size up to 10 workers).

The average shares of these measures of informality for each country are:

- Mexico: $\bar{h}_1^i = 0.40$ $\bar{h}_2^i = 0.21$ $\bar{h}_3^i = 0.19$ $\bar{h}_4^i = 0.26$ $\bar{h}_5^i = 0.23$ $\bar{h}_6^i = 0.28$
- Colombia: $\bar{h}_1^i = 0.50$ $\bar{h}_2^i = 0.80$
- South Africa: $\bar{h}_1^i = 0.20$

[9] Note that we follow Fernandez and Meza (2015)'s work to measure the informal employment for Mexico. Although they obtain the same data we have, they do not present all in their paper.

[10] We also found the data on total employment(Th) in national from GEIH, but we are not able to obtain the informal employment in total national.

[11] 'Informal employment identifies persons who are in precarious employment situations irrespective of whether or not the entity for which they work is in the formal or informal sector. Persons in informal employment therefore comprise all persons in the informal sector, employees in the formal sector, and persons working in private households who are not entitled to basic benefits such as pension or medical aid contributions from their employer, and who do not have a written contract of employment.' For details about the definition of informal sector, see Stat SA-Quarterly Labor Force Survey.

[12] Informal employment is persons who are not registered to any social security institution due to the main job in the reference week. Note that the data we obtained from TurkStat is monthly. We converted it quarterly data by taking the average.

- Turkey: $\bar{h}^i_1 = 0.26$, $\bar{h}^i_2 = 0.64$, $\bar{h}^i_3 = 0.61$
where $\bar{h}^i_x \equiv \Sigma^{T_x}_{t=1} h^i_{x,t}/(h^i_{x,t} + h^f_{x,t})$ for $x = 1, ..., j$, and T_x is the maximum sample size in measure x. i stands for informal and f for formal. As can be seen, the average share of informal employment in these economies are very large and different, especially in Colombia and Turkey. Note that presenting these shares is important because we define the average share of informal employment for each country in steady state to solve the model later on.

3.2.2 The Stylized Facts

In Table 3.1, 3.2, 3.3 and 3.4, we report the standard deviation and pro-cyclicality of output, consumption, investment, trade balance share, total employment, and informal employment in EMEs. Figure 3.1, 3.2, 3.3, and 3.4 in Appendix 3.A, we present the cross-correlation between output and informal employment for each country. Our starting point is the comparison of emerging market business cycle statistics with those of Canada (see Table 3.5). Emerging markets and business cycles differ in many dimensions: 1) The volatility of employment relative to output in Mexico (0.39) is lower compared to Canada (0.57) but in Colombia (1.35), South Africa (1.70) and in Turkey (0.91) is much higher. 2) Employment in Mexico (0.58), Colombia (0.40), South Africa (0.45) and Turkey (0.17) displays a correlation with the cycle that is considerably lower than that of Canada (0.74). 3) The volatility of consumption relative to output in these economies is more volatile than that of Canada. 4) Emerging economies have the higher volatility of output. 5) A distinguishing feature of business cycles in these economies is the larger and negative correlation of trade balance share and output compared to Canada.

Table 3.1: Mexico (2000-2010)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(i)$	$\rho(h^i_5, i)$
Y	1.96			0.88	
C		1.20	0.96		
I		2.10	0.86		
NX/Y		0.37	-0.46		
h	0.86	0.39	0.58		0.16
h^f_5	1.12	0.56	0.86		-0.43
h^i_5	2.61	1.30	-0.44		1

We claim that the large share of informal employment in EMEs plays a significant role in explaining labour market dynamics over the business cycle in these economies.

Table 3.2: Colombia (2007-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(i)$	$\rho(h_2^i,i)$
Y	1.17			0.77	
C		0.98	0.85		
I		3.75	0.87		
NX/Y		0.71	-0.46		
h	1.58	1.35	0.40		0.53
h_2^f	7.36	6.30	0.21		0.66
h_2^i	2.31	1.97	-0.04		1

Table 3.3: South Africa (2008-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(i)$	$\rho(h_1^i,i)$
Y	1.01			0.83	
C		1.53	0.85		
I		3.70	0.66		
NX/Y		0.85	-0.36		
h	1.74	1.70	0.45		0.48
h_1^f	1.81	1.76	0.38		0.14
h_1^i	3.17	3.06	0.39		1

Table 3.4: Turkey (2005-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(i)$	$\rho(h_2^i,i)$
Y	3.15			0.81	
C		1.01	0.88		
I		2.69	0.92		
NX/Y		0.52	-0.36		
h	2.91	0.91	0.17		0.34
h_2^f	3.58	1.13	0.41		0.16
h_2^i	3.40	1.07	-0.33		1

Table 3.5: Canada (2002-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(i)$
Y	1.13			0.86
C		0.66	0.66	
I		3.36	0.89	
NX/Y		0.53	-0.02	
h		0.57	0.74	

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of X. $\rho(x,y)$ denotes the correlation between the cyclical components of x and y. Variables Y, C, I, NX, and h stand for quarterly data on output, consumption, investment, net exports and total employment. People are self-employed in the informal sector (h_j^i). h_j^f refers to the residual when each of the series on informal employment are subtracted from total employment The series are logged first except for the ratio NX and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

However, less attention has been given to the business cycle dynamics of informal employment. Therefore, we document the informal employment as it also has distinctive dynamics over the business cycle. The results show that the behaviour of informal employment varies depending on the measure and the country.[13] That might be a challenge for us to evaluate the model regarding its performance along the second moments for these economies. Hence, we assume that people are self-employed in the informal sector as it is a good proxy for informality in these economies. We then evaluate the performance of the model for h_5 in Mexico, h_2 in Colombia and h_2 in Turkey which shows the results for informality in self-employment. For South Africa, we only have one informality measure which is informality in non-agricultural.

Based on this measure, informal employment in Mexico is strongly countercyclical (-0.44) and negatively correlated with the formal employment (-0.43). In addition, we observe in Figure 3.1 that it is a lagging indicator of the cycle in Mexico. For Colombia, informal employment is positively correlated with the formal employment (0.66) and leads the cycle slightly in Figure 3.2. In South Africa, it is pro-cyclical (0.39) and positively correlated with the formal employment (0.14) and is a leading indicator of the cycle in Figure 3.3. Lastly, it is countercyclical in Turkey (-0.33) and is positively correlated with the formal employment (0.16). Also, informal employment is a lagging indicator of the cycle for the measure of self-employment in Figure 3.4.

Moreover, informal employment is more volatile than formal employment in Mexico (1.30 vs 0.56) and South Africa (3.06 vs 1.76). In Colombia, it is much less than formal

[13] For the details, see Table 3.12, 3.13, 3.14 and 3.15 in Appendix 3.A. As it can be seen that the results are not robust across all measures of informal employment, especially for Mexico. Informal employment for h_4 and h_6 is strongly countercyclical and negatively correlated with the formal employment as in h_5. However, informal employment for h_1, h_2 and h_3 is pro-cyclical and positively correlated with the formal employment.

employment (1.97 vs 6.30). For Turkey, it is slightly lower than formal employment (1.07 vs 1.13). Finally, the data shows that informal employment acts as a buffer for Mexico and South Africa regarding volatilities because we find that informal employment is more volatile than formal employment. Also, we observe that informal employment is counter-cyclical and formal employment is pro-cyclical in Mexico (-0.44 vs 0.86), Colombia (-0.04 vs 0.21) and Turkey (-0.33 vs 0.41) which confirm that informal employment acts as a buffer for these economies as well.

We explore that business cycle fluctuations are different among emerging economies. We claim that the differences in the degree of employment protection among countries can explain the differences in data moments. In Table 3.6, we hence present severance pay for redundancy dismissal (in salary week) for these economies. It shows that employment protection is high and different among these economies. This observation also helps us to build our model in the next section to answer our research questions in the paper.

TABLE 3.6: Employment Protection

Redundancy Cost Indicator (in salary week)	Mexico	Colombia	South Africa	Turkey
1 year of tenure	14.6	4.3	1.0	4.3
5 years of tenure	21.4	15.7	5.0	21.7
10 years of tenure	30.0	30.0	10.0	43.3
Average	22.0	16.7	5.3	23.1

Note: The World Bank publishes as part of the Doing Business Indicators (2017) as a measure of the monetary costs in terms of weeks of severance payments due for firing a worker, averaged across workers of 1, 5, and 10 years of tenure.

3.3 The Model

We build a small open economy model with formal and informal labour markets that follows the framework of Fernandez and Meza (2015). We assume that households choose how much labour to allocate to each market. Maloney (2004) finds that there is no segmentation between formal and informal labour markets, based on the patterns of workers' mobility between the two markets.[14] Preferences are of the GHH type (see Greenwood, Hercowitz, and Huffman (1988b)'s work). There are two consumption goods produced in the two sectors. Households accumulate two different capital stocks, which are market specific and choose which sector to allocate it. The characteristics of the informal sector in EMEs is small, unsophisticated technologies and low capital

[14]See Pratap and Quintin (2006), Levy (2008) and Bosch and Maloney (2008) who show the high transition rates across the formal and informal market in EMEs.

requirements per worker. Therefore, we assume that informal sector can only produce elementary low-tech machinery for most simple operations that is likely to be used in basic labour-intensive sector.[15] We also assume that informal sector goods are non-tradable.

Households can buy or sell one-period non-contingent bonds in foreign capital markets. Regarding production, goods in the formal sector are produced by firms. In the informal sector, people are self-employed. Both technologies have constant returns to scale and use capital and labour in production. The formal firm pays taxes on the wage bill but enjoys higher productivity levels compared to the informal sector. The informal self-employed producer faces a lower productivity level but does not pay taxes. The formal sector technology faces two shocks. As in Aguiar and Gopinath (2007), there are temporary productivity shocks and shocks to the growth rate of labour augmenting productivity. These shocks in the formal sector are pass-through to the informal sector. That is, the shocks to both markets are imperfectly correlated.[16]

The contribution of our paper is to postulate a quadratic labour adjustment costs function in the production of formal and informal goods following Fairise and Langot (1994b) and Janko (2008). These costs play an important role in affecting the firm's production process. Specifically, the response of labour and thus output of the firm will change. We introduce these costs in our analysis as strict employment protection in EMEs, measured as a larger number of weeks of wages paid by firms in the event of a separation. As we already mentioned in data section, the differences in the degree of employment protection among countries can explain the differences in data moments between EMEs. This then allow us to explore which extent the informal sector acts as a buffer for the formal sector, given that level of protection. Also, in our benchmark model, we assume that both sectors have labour adjustment costs which are the same. We do so in order to provide a quantitative sense of how both sectors will adjust when they face shocks. Later on, we consider robustness analysis for the role of these costs. Finally, the government taxes personal income (wages and capital rents) and the hiring of labour by formal firms.

[15]Chattopadhyay and Mondal (2017) explain that 'physical capital is more likely to be immobile across sectors as the machines that are used in the informal sector cannot be re-modelled to be used in formal sector at all or vice-versa.' In addition, if an informal firm produces simple machinery that is not certified according to national standards and is subsequently used by another informal firm which does not aspire at certification of their own output. Therefore, we assume that informal sector uses low-tech elementary machinery for most simple operations. Note that there is no restriction if an informal sector is in manufacturing or services.

[16]See Fernandez and Meza (2015). They explain that 'this assumption captures institutional or other types of barriers that prevent driving forces of business cycles from fully spreading across formal and informal markets uniformly.' As an example, technological innovations occur in the formal market but take time for informal sector to be acquired resources.

3.3.1 The representative household

The representative household has a lifetime expected utility

$$U = E_0 \sum_{i=0}^{\infty} \beta^t \; u(C_t^A, h_t^A), \tag{3.3.1}$$

where we use a GHH utility function for $u(.)$:[17]

$$U(C_t^A, h_t^A) = \frac{(C_t^A - \Gamma_{t-1}^F (h_t^A)^{\kappa})^{1-\sigma} - 1}{1-\sigma},$$

Γ_{t-1}^F is (trending) labour productivity in the formal sector. We include it in the utility function to achieve a balanced growth path. The discount factor β takes values between 0 and 1. Aggregate labour is denoted by h_t^A, and is defined as the sum of labour in the formal and informal sectors, denoted h_t^F and h_t^I, respectively:

$$h_t^A = h_t^F + h_t^I. \tag{3.3.2}$$

C_t^A is aggregate consumption modeled as a CES aggregator of the formal and informal consumption goods C_t^F and C_t^I, respectively:

$$C_t^A = (a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} \tag{3.3.3}$$

κ>1, σ>0, and a∈[0,1] determine the wage elasticity of labour supply, the intertemporal elasticity of substitution $(1/\sigma)$, and the weight of each consumption good in the CES aggregator, respectively. The elasticity of substitution between formal and informal goods is $1/(1-e)$.

The budget constraint is

$$q_t D_{t+1} = C_t^F + p_t C_t^I + I_t^F + p_t I_t^I + D_t - (W_t h_t^F + r_t K_t^F)(1-\tau^Y) - p_t Y_t^I. \tag{3.3.4}$$

The numeraire is the formal good. The relative price of the informal good is p_t. D_{t+1} is the stock of debt the household can issue at a price q_t in world markets in t to be redeemed in $t+1$. I_t^F is investment in the formal sector. I_t^I is investment in the informal sector. W_t is the real wage per unit of labour in the formal sector. r_t is the rental rate of the capital to the formal firm K_t^F. Y_t^I is the amount of income generated in the informal sector. τ^Y is the income tax rate applied to flows of income from the formal sector.

[17]This utility function has been used extensively in small open economy models to mitigate the impact of wealth effects on labor supply.

The representative household faces a technology in the informal sector given by

$$Y_t^I = z_t^I (K_t^I)^{\alpha_I} (\Gamma_t^I h_t^I)^{1-\alpha_I} - \Gamma_{t-1}^F \chi^I (\frac{h_t^I}{h_{t-1}^I} - 1)^2 h_t^I \tag{3.3.5}$$

where K_t^I is the stock of capital used by the informal sector. z_t^I are the temporary productivity shocks in the informal sector. Γ_t^I is the labour augmenting productivity process. We include Γ_{t-1}^F in the adjustment cost function to achieve balance growth. The informal capital income share is α_I. χ^I is the labour adjustment cost parameter in the informal sector. When χ^I>0 firms incur positive labour adjustment costs whenever informal labour differ across periods. The adjustment cost function is convex, symmetric and exhibits constant return to scale in its inputs. The characteristic of the labour adjustment cost function is that today's labour affects not only today's labour adjustment costs but next period's costs as well (see Janko (2008)).

We assume that the laws of motion for the capital stock in the formal and informal sectors are respectively

$$K_{t+1}^F = I_t^F + (1 - \delta^F) K_t^F, \tag{3.3.6}$$

$$K_{t+1}^I = I_t^I + (1 - \delta^I) K_t^I, \tag{3.3.7}$$

where the depreciation rate (δ) is $0<\delta < 1$.

3.3.2 The representative formal firm

The representative firm that operates in the formal sector maximizes profits II_t each period t, defined as

$$\text{II}_t = Y_t^F - (1 + \tau^N) W_t h_t^F - r_t K_t^F, \tag{3.3.8}$$

where τ^N is the tax on the wage bill. The level of taxes is important because if taxes on labour income are high in the formal sector, then informal sector will be more attractive for workers as they can earn more by working at the same job informally. Employers also have an incentive to evade this tax, for the same reason. The technology faced by the formal sector is given by

$$Y_t^F = z_t^F (K_t^F)^{\alpha_F} (\Gamma_t^F h_t^F)^{1-\alpha_F} - \Gamma_{t-1}^F \chi^F (\frac{h_t^F}{h_{t-1}^F} - 1)^2 h_t^F, \tag{3.3.9}$$

where z_t^F are the temporary productivity shocks and Γ_t^F is a labour augmenting productivity process in the formal sector. We allow for a different capital income share α_F than in the informal sector.

3.3.3 Government

The government runs a balanced budget in every period:

$$\tau^N W_t h_t^F + (W_t h_t^F + r_t K_t^F)\tau^Y = G_t, \tag{3.3.10}$$

where government spending G_t equals total tax revenue. We assume public expenditure is entirely in formal goods.

3.3.4 Interest rates

The interest rate on the debt issued in world capital markets is equal to the inverse of the price of the debt, which we assume to be equal to a constant interest rate and an interest premium. We assume that

$$1/q_t = R + \widetilde{\psi}(\widetilde{D}_{t+1}/\Gamma_t^F) \tag{3.3.11}$$

where $\psi(\widetilde{D}_{t+1}/\Gamma_t^F)$ is an aggregate-debt elastic premium stemming from deviations from a long run level of debt, and R is the interest rate that the small open economy faces in world capital markets. Following Schmitt-Grohe and Uribe (2003) we define $\widetilde{\psi}(.)$ as follows

$$\widetilde{\psi}(\widetilde{D}_{t+1}/\Gamma_t^F) = \psi[exp(\widetilde{D}_{t+1}/\Gamma_t^F - d) - 1] \tag{3.3.12}$$

with $\widetilde{\psi}$>0, and d being the long run (de-trended) steady state level of debt. Note that, in equilibrium, aggregate debt $\widetilde{D}_{t+1}$ and consumer's debt D_{t+1} coincide.

3.3.5 Balance of payments

Net exports equal the change in debt plus interest payments

$$nx_t = D_t - q_t D_{t+1} \tag{3.3.13}$$

3.3.6 Formal and informal market clearing

Market clearing in the goods market for both types of goods are:

$$Y_t^F = C_t^F + I_t^F + G_t + D_t - q_t D_{t+1}, \tag{3.3.14}$$

$$Y_t^I = C_t^I + I_t^I, \tag{3.3.15}$$

Hence we define the trade balance share as

$$\begin{aligned} nxy_t &= \frac{D_t - q_t D_{t+1}}{Y_t^F} \\ &= \frac{Y_t^F - C_t^F - I_t^F - G_t}{Y_t^F} \end{aligned}$$

Total aggregate output is defined as

$$Y_t^A = Y_t^F + p_t Y_t^I. \tag{3.3.16}$$

3.3.7 Productivity process

We introduce temporary shocks in the formal and informal sectors, respectively. z_t^F is assumed to follow an AR(1) process

$$ln(z_{t+1}^F) = \rho_z ln(z_t^F) + \varepsilon_{t+1}^z, \tag{3.3.17}$$

with $0 < \rho_z < 1$ and the variance of the shock is $\varepsilon_z^2 > 0$. The process for the informal temporary technology process is a function of its previous value and of the current temporary value of the process in the formal sector:

$$z_t^I = (z_{t-1}^I)^{1-\omega_z} (\gamma z_t^F)^{\omega_z},$$

where we assume that the degree of pass-through of shocks is governed by ω_z. Also, γ governs the productivity gap between the two temporary shocks in steady state.

We assume a process for the growth factor of productivity in the formal sector

$$\frac{\Gamma_t^F}{\Gamma_{t-1}^F} = g_t^F, \tag{3.3.18}$$

where g_t^F is assumed to follow an AR(1) process:

$$ln(g_{t+1}^F/\mu) = \rho_g ln(g_t^F/\mu) + \varepsilon_{t+1}^g,$$

with $0<\rho_g<1$ and variance of the shock $\sigma_g^2>0$. We call ε_{t+1}^g a growth shock. Parameter μ is the long-run growth factor of labor augmenting productivity.

We assume that growth shocks in the formal sector relates to the informal sector as follows:

$$\frac{\Gamma_t^I}{\Gamma_{t-1}^I} = g_t^I,$$

$$g_t^I = (g_{t-1}^I)^{1-\omega_g}(g_t^F)^{\omega_g},$$

We also assume that growth shocks in the formal sector are passed through to the informal sector with an elasticity of ω_g, with $0<\omega_g<1$. We include this mechanism in the model because we would like to allow for an imperfect propagation of these shocks from the formal to the informal sector, hence generating incentives for labour to reallocate across sectors in equilibrium.

We can express the levels of labor-augmenting productivity in both sectors as a product of the growth shocks:

$$\Gamma_t^I = \Gamma_0^I \prod_{j=1}^{t} g_j^I,$$

$$\Gamma_t^F = \Gamma_0^F \prod_{j=1}^{t} g_j^F,$$

We assume that the initial difference between Γ_0^F and Γ_0^I is pinned down by a parameter γ via $\Gamma_0^I = \gamma\ \Gamma_0^F$. Parameter γ, with $0<\gamma<1$, governs the productivity gap between the two sectors in the steady state. Last, we assume that in the long run:

$$\frac{\Gamma_t^F}{\Gamma_{t-1}^F} = \frac{\Gamma_t^I}{\Gamma_{t-1}^I} = \mu. \tag{3.3.19}$$

which allows us to compute a balanced growth path equilibrium.[18]

[18] See Appendix 3.B for the solution of the model.

3.4 Calibration

We calibrate the parameters using a stationary system of equations evaluated at non-stochastic steady state. The calibrated values are reported in Table 3.7. These values are fit for quarterly frequency in EMEs.

We set parameter σ, which shows the inter-temporal elasticity of substitution, $\frac{1}{\sigma}$, equal to 2 implying an elasticity of 0.5. Parameter κ determines the wage elasticity of labour supply, equal to 1.6 following Aguiar and Gopinath (2004) estimated on the Mexican economy. Regarding the depreciation rate δ and the average growth factor μ, we set them equal to 5 percent and 1.006, respectively following Aguiar and Gopinath (2007). Note that we assume that there is an identical depreciation rate for the two types of capital.

We set the constant gross interest rate R paid by the economy in world capital markets to 1.0145. Fernandez and Meza (2015) use the data on country interest rates for Mexico from Uribe and Yue (2003) and find this value. Then we calculate discount factor β from the stationary Euler equation for debt evaluated at the steady state $\beta = \frac{1}{R\mu^{-\sigma}}$. Its value equal to 0.9976. We set the interest rate premium parameter ψ to 0.00001 as in Schmitt-Grohe and Uribe (2003).

We calibrate tax wage bill τ^N to 0.1142 and the income tax rate applied to flows of income from the formal sector τ^Y to 0.0722. To calculate these values, Fernandez and Meza (2015) find the data on tax collection regarding the payments that firms make as social contributions, and on tax base for τ^N and the ratio of aggregate individual tax revenue to the sum of wages and salaries, and household income from capital for τ^Y using annual data from 2003 to 2008 for Mexico. We have to use the same values for the rest of the countries in our analysis because we could not find the data to calculate these values for Colombia, South Africa and Turkey.

We set e to 0.875 which governs the elasticity of substitution between formal and informal goods implying an elasticity of 8. Restrepo-Echavarria (2014) argues that formal and informal goods are close substitutes. We set the capital income share in the formal sector α_F to 0.35 following Comin, D., and Gertler, M. (2006). We set the capital income share in the informal sector α_I to 0.2 following Restrepo-Echavarria (2014) who uses this value by citing the evidence that informal production is less capital intensive.

To pin down the value of a, we use non-stochastic steady state of the model which includes the average share of informal employment for these economies. From our data, we find the average shares as 0.26 for Mexico, 0.65 for Colombia, 0.20 for South Africa, and 0.50 for Turkey. Then, we obtain the share of formal goods in aggregate consumption a to 0.2902 for Mexico, 0.2492 for Colombia, 0.3007 for South Africa, and 0.2640 for Turkey.

We calibrate the persistence of the growth shock ρ_g to 0.72 and the persistence of

Table 3.7: Benchmark model calibration

Parameters	Definition	Value
e	the elasticity of substitution between formal and informal goods 1/(1-e)	0.875
τ^N	the tax on the wage bill	0.1142
τ^Y	the income tax rate applied to flows of income from the formal sector	0.0722
α_F	capital income share in formal sector	0.35
σ	the intertemporal elasticity of substitution $(1/\sigma)$	2
δ	depreciation rate in formal sector	0.05
κ	the wage elasticity of labor supply	1.6
ψ	interest rate debt elasticity	0.00001
μ	long run productivity growth factor	1.006
R	external interest rate	1.0145
β	discount rate	0.9976
α_I	capital income share in informal sector	0.20
γ	productivity gap between formal and informal technology	0.0198
d	steady state debt to (formal) income	0.10
ρ_g	persistence of growth shocks	0.72
ρ_a	persistence of temporary shocks	0.94

the temporary shock ρ_z to 0.94 as in Aguiar and Gopinath (2004). For the debt level in the interest rate premium, we choose the number as the debt to GDP ratio. It is equal to 0.10 as in Aguiar and Gopinath (2007).

To calibrate the productivity gap between formal and informal technology γ, we use the production functions of the two sectors. In the steady state the ratio of formal and informal total factor productivity levels is:

$$\frac{TFP^F}{TFP^I} = \frac{\mu^{-\alpha_F+\alpha_I}}{\gamma^{\alpha_I}}$$

Busso, Fazio, and Algazi (2012) use the firm-level measures of total factor productivity in Mexico and set $\frac{TFP^F}{TFP^I}$ as 2.1901. Then we find the productivity gap between formal and informal technology as 0.0198.

We estimate pass-through of the two driving forces from formal to informal sectors (ω_g and ω_a), the standard deviation of shocks (σ_g and σ_z) and labour adjustment cost in both sectors (χ^F and χ^I) to match a specific subset of moments from the data. That is, we use GMM estimation. Formally we calibrate these parameters by solving

$$\min_{\omega_g,\omega_a,\sigma_z,\sigma_g,\chi^F,\chi^I} \left[\frac{M_j(\omega_g,\omega_a,\sigma_z,\sigma_g,\chi^F,\chi^I)-M_j^d}{M_j^d}\right]' H_j \left[\frac{M_j(\omega_g,\omega_a,\sigma_z,\sigma_g,\chi^F,\chi^I)-M_j^d}{M_j^d}\right].$$

where M_j^d denotes the j^{th} subset of moments in the data, $M_j(\omega_g,\omega_a,\sigma_z,\sigma_g,\chi^F,\chi^I)$ is its model counterpart, and H_j is a weighting matrix associated with j. The vector contains 14 moments.[19] In the next section, we document sensitivity results using alternative specifications for M_j^d and H_j. We solved this minimization problem by postulating a grid for each of these parameters and computing the minimum element among all possible elements of the grid. The reason why we follow this procedure is that these parameter values are not standard in the literature. We would like to assess how much information about these parameter values we could bring when taking the model to the data.

3.5 Results

Table 3.8, 3.9, 3.10 and 3.11 report several business cycle statistics for the EMEs which are computed from the data simulated from the benchmark model. Then we compare the empirical second moments with the theoretical ones derived from the model. All moments are computed on the HP-filtered variables. We estimate our benchmark model by assuming that both sectors have the same labour adjustment costs (χ^F=χ^I) as well as the degree of propagation of shocks from the formal to the informal sector is the same across shocks (ω_a= ω_g). However, for robustness, we first check our results by assuming that there is no LACs in the informal sector while all the parameter values are the same as in the benchmark model (Case 1). Note that the estimated parameter values for LACs in these economies is consistent with the figures we presented in Table 3.6 for employment protection. More specifically, severance pay for redundancy dismissal (in salary week) is 22.0 (Mexico), 23.1 (Turkey), 16.7 (Colombia) and 5.3 (South Africa) while the estimated parameter values for LACs is 0.79 (Mexico and Turkey), 0.59 (Colombia) and 0.21 (South Africa). We then estimate the model by assuming that labour adjustment costs are not equal to each other between sectors ($\chi^F \neq \chi^I$) while the degree of propagation of shocks from the formal to the informal sector is the same across shocks (ω_a= ω_g) (Case 2). We find that the costs in the formal sector are larger than in the informal one. Lastly, we estimate the model by assuming that the pass-through of both shocks from the formal

[19]The model is estimated to match all moments we presented in tables except the correlation between informal and formal employment.

to the informal sector is different ($\omega_a \neq \omega_g$) as well as LACs are not equal to each other among sectors ($\chi^F \neq \chi^I$) (Case 3). In the context of these models, we investigate two related questions: what are the effects of changes in the degree of employment protection on the informal employment and the business cycles in EMEs? And, given that level of protection, to which extent the informal sector acts as a buffer in the face of adverse shocks to the labour market?

Note that it is difficult to demonstrate to what extent the informal sector is measured in the national accounts of a country. Restrepo-Echavarria (2014) points out the lack of reliable estimates from household surveys makes accounting for the informal economy in the national accounts difficult. Therefore, we make a one-to-one mapping between aggregate data output and consumption and the model's level of formal output and consumption as in Restrepo-Echavarria (2014) and Fernandez and Meza (2015). However, we observe that the results do not change significantly between the model's level of total output and consumption and the model's level of formal output and consumption. For example, we find that the formal output and consumption volatility in the estimated model for Mexico is 1.71 and 1.12, respectively while the total output and consumption volatility is 1.65 and 0.96, respectively. Moreover, these slight changes do not have almost any impact on other results.

The model matches the data reasonably well. The benchmark model produces satisfactorily the pro-cyclicality of formal employment in Mexico, the high output volatility in Mexico and South Africa, and high consumption volatility in Mexico and Turkey. It is also capable of simultaneously matching the persistence of output as well as the pro-cyclicality of consumption in all these economies. Moreover, it generates satisfactorily the pro-cyclicality of total employment in Colombia. In this model, our observation is that the pro-cyclicality of formal employment and total employment in Mexico are more pronounced and the volatility of formal employment is lower compared to Colombia even though their pass-through of shocks and standard deviations of shocks are almost the same. The reason might be that Colombia has lower LACs than the ones in Mexico, which leads to higher formal employment volatility but lower pro-cyclicality of total employment and formal employment in Colombia. On the other hand, South Africa has the similar results to Mexico regarding these facts although the LACs in South Africa is much smaller than Mexico and Colombia. It should be noted that the standard deviation of growth shocks in South Africa is lower compared to the one in Mexico and Colombia. Hence, we can conclude that the value of LACs is important, however, the size of the shocks has an influence on these facts compared to LACs. In addition, in the estimated benchmark model we observe that informal employment acts as a buffer as it is countercyclical while formal employment is pro-cyclical. This supports the evidence in the data for these economies except for South Africa. Regarding volatilities, the model shows that the formal employment is more volatile than the informal employment. That is, informal employment does not act as a buffer in the formal sector which contrasts with the evidence in the data for these economies except Colombia.

Normally, it is known that the informal sector provides more flexibility to the economy to accommodate shocks, helping to smooth the impact of business cycles on the labour market. However, we assume that there is a cost in the formal sector (Case 1). If the adjustment costs are only in the formal sector, we observe that the impact of shocks are lower. Thereby, the informal employment is pro-cyclical which replicates the data fact well for South Africa and is positively correlated with the formal employment which matches with the evidence well for Colombia and Turkey. In addition, it explains satisfactorily the pro-cyclicality of total employment in Mexico and Colombia. We also find that the volatility of informal employment (formal employment) in Case 1 is more (slightly less) volatile than in that of benchmark model. This is a consequence of employment protection in the formal sector which will not allow firms to fire workers when there is a negative shock to the economy as it is costly. Moreover, output is less volatile in Case 1 compared to the benchmark model but we see that it is more volatile if a country has a higher employment protection in Case 1. In addition, we find that informal employment is more volatile than formal employment for these economies except for Turkey. Our observation is that the pass-through of the shocks from the formal to the informal sector (ω_a=ω_g=ω) are important in this model because the value of ω is lower in Turkey (0.68) compared to the other economies (0.95). It implies that 32 percent of a shock in the formal sector for Turkey is not contemporaneously propagated into the informal sector. We observe that the lower values of ω translate into stronger volatility in labour markets. Therefore, the volatility of formal employment and total employment are higher, but the volatility of informal employment is lower in Turkey compared to the other economies. This also explains why the output volatility is higher and pro-cyclicality of informal employment is lower in Turkey compared to other economies. Lastly, in the estimated model, we find that informal employment does not act as a buffer as the formal employment is more pro-cyclical than in that informal one (except for Colombia) which contrasts with the evidence in the data. However, with regard to the volatilities, the informal employment is more volatile than formal employment (except for Turkey) which supports informal employment acts as a buffer as in the data. Note that the results are reversed compared to the benchmark model regarding the buffer effect.

In Case 2, we find that LACs in the formal sector is higher than in that of the informal sector. This model matches well the counter-cyclicality of informal employment in Mexico and Turkey. We also find that the counter-cyclicality of trade balance share matches the data well in Colombia and Turkey. We observe that the size of the LACs in the formal sector and shocks are higher in this model compared to the benchmark case. It hence increases the volatility of output significantly which contradicted by the data for all these economies except Turkey. This shows that we need a lower standard deviation of shocks to produce the output volatility for Mexico, Colombia and South Africa. Also, we observe that the model with informal sector acts as powerful propagation mechanism for shocks. For this analysis, we compare our results with Aguiar and Gopinath (2007)'s work (AG). They built a small open economy model with temporary and trend shocks to productivity. Then, they estimate the standard deviation of shocks as $\sigma_a = 0.41$ and $\sigma_g = 1.09$, respectively. However, we find that the model with LACs which has lower σ_a and σ_g can produce some of the facts they presented in the paper such as high output and consumption volatility as well as high pro-cyclicality of consumption. As in AG, we also find that growth shocks are relatively more important than temporary shocks. That is, growth shocks are the main drivers of aggregate fluctuations in these economies. Regarding the buffer effect, we obtain similar results in the estimated benchmark model except South Africa which has a lower standard deviation of permanent shock compared to the other economies.

In our last model, we would like to show how the results change when the pass-through of both shocks from the formal to the informal sector is different as well as LACs are not equal to each other among sectors (Case 3). That is, there is a specific parameter ω for temporary (ω_a) and growth shocks (ω_g). We include this mechanism in the model because we would like to allow for an imperfect propagation of these shocks from the formal to the informal sector, hence generating incentives for labour to reallocate across sectors. We find that this model produces the negative (positive) relationship between formal and informal employment in Mexico (Colombia). It can also generate the relative volatility of formal employment and total employment are much closer to the data for Mexico. We find lower ω_a and ω_g in this model when compared to the benchmark model where we assume that both are equal to each other. Our observation is that, as ω_a and ω_g are reduced, the output volatility and the relative volatility of formal, informal and total employment increase as well as formal (informal) employment becomes more pro-cyclical (counter-cyclical) in these economies. Only in Mexico, we find that output volatility decreases. This might be due to the fact that the value of ω_g is higher than the value of ω_a in Mexico, therefore the model generates lower output volatility as well as less formal and informal volatility when compared to the model which has lower ω_g than ω_a.

To summarize, we explore that (1) a country which has a lower LACs leads to higher formal employment volatility and lower counter-cyclicality of informal employment as well as lower pro-cyclicality of total employment and formal employment (2) the standard deviation of shocks has an effect on these facts compared to the LACs (3) if there is only LACs in the formal sector, the informal employment is pro-cyclical and more volatile than in the that of LACs in both sectors (4) a country which has a higher employment protection in the formal sector leads output more volatile (5) labour market variables are

Table 3.8: Business Cycle Moments: Mexico

		Benchmark	Case 1	Case 2	Case 3
			Estimated Parameters		
	ω_a	0.95	0.95	0.95	0.14
	ω_g	0.95	0.95	0.95	0.77
	$100 * \sigma_a$	0.01	0.01	0.10	0.10
	$100 * \sigma_g$	0.24	0.24	0.33	0.16
	χ^F	0.79	0.79	0.99	0.99
	χ^I	0.79	-	0.40	0.40
	a	0.2915			
			Second moments		
	Data		Model		
$\sigma(Y^F)$	1.96	1.71	1.65	2.50	1.40
$\sigma(C^F)/\sigma(Y^F)$	1.20	1.12	1.14	1.07	0.97
$\sigma(I^F)/\sigma(Y^F)$	2.10	6.72	6.38	6.60	6.87
$\sigma(TBY^F)/\sigma(Y^F)$	0.37	1.94	1.89	1.90	1.93
$\rho(Y^F)$	0.88	0.96	0.96	0.96	0.96
$\rho(C^F, Y^F)$	0.96	0.97	0.96	0.97	0.95
$\rho(I^F, Y^F)$	0.86	0.38	0.42	0.39	0.35
$\rho(TBY^F, Y^F)$	-0.46	-0.26	-0.28	-0.25	-0.19
$\sigma(h^A)/\sigma(Y^F)$	0.39	0.16	0.22	0.21	0.31
$\rho(h^A, Y^F)$	0.58	0.79	0.68	0.74	0.79
$\sigma(h^F)/\sigma(Y^F)$	0.56	0.22	0.17	0.28	0.43
$\sigma(h^I)/\sigma(Y^F)$	1.30	0.07	0.48	0.10	0.13
$\rho(h^F, Y^F)$	0.86	0.84	0.87	0.79	0.90
$\rho(h^I, Y^F)$	-0.44	-0.70	0.32	-0.42	-0.76
$\rho(h^I, h^F)$	-0.43	-0.69	0.62	-0.70	-0.40

Note: In our benchmark model, we assume that $\omega_a = \omega_g$ and $\chi^F = \chi^I$. In Case 1, there is only an adjustment cost in the formal sector. In Case 2, we assume that $\omega_a = \omega_g$ but $\chi^F \neq \chi^I$. In Case 3, we assume that $\omega_a \neq \omega_g$ and $\chi^F \neq \chi^I$.

Table 3.9: Business Cycle Moments: Colombia

		Benchmark	Case 1	Case 2	Case 3
			Estimated Parameters		
	ω_a	0.95	0.95	0.95	0.32
	ω_g	0.95	0.95	0.95	0.14
	$100 * \sigma_a$	0.06	0.06	0.10	0.10
	$100 * \sigma_g$	0.22	0.22	0.33	0.25
	χ^F	0.59	0.59	0.99	0.99
	χ^I	0.59	-	0.79	0.79
	a	0.2502			
			Second moments		
	Data		Model		
$\sigma(Y^F)$	1.17	1.60	1.37	2.43	2.91
$\sigma(C^F)/\sigma(Y^F)$	0.98	1.61	1.83	1.60	0.75
$\sigma(I^F)/\sigma(Y^F)$	3.75	6.48	5.85	6.40	6.69
$\sigma(TBY^F)/\sigma(Y^F)$	0.71	2.12	2.15	2.10	1.80
$\rho(Y^F)$	0.77	0.96	0.97	0.97	0.95
$\rho(C^F, Y^F)$	0.85	0.88	0.78	0.87	0.90
$\rho(I^F, Y^F)$	0.87	0.41	0.50	0.42	0.33
$\rho(TBY^F, Y^F)$	-0.46	-0.33	-0.38	-0.34	-0.08
$\sigma(h^A)/\sigma(Y^F)$	1.35	0.15	0.27	0.15	0.28
$\rho(h^A, Y^F)$	0.40	0.55	0.53	0.56	0.83
$\sigma(h^F)/\sigma(Y^F)$	6.30	0.36	0.38	0.37	0.71
$\sigma(h^I)/\sigma(Y^F)$	1.97	0.07	0.40	0.07	0.19
$\rho(h^F, Y^F)$	0.21	0.64	0.29	0.64	0.98
$\rho(h^I, Y^F)$	-0.04	-0.06	0.40	-0.04	-0.14
$\rho(h^I, h^F)$	0.66	-0.09	0.68	-0.07	0.65

Note: In our benchmark model, we assume that $\omega_a = \omega_g$ and $\chi^F = \chi^I$. In Case 1, there is only an adjustment cost in the formal sector. In Case 2, we assume that $\omega_a = \omega_g$ but $\chi^F \neq \chi^I$. In Case 3, we assume that $\omega_a \neq \omega_g$ and $\chi^F \neq \chi^I$.

Table 3.10: Business Cycle Moments: South Africa

		Benchmark	Case 1	Case 2	Case 3
			Estimated Parameters		
	ω_a	0.95	0.95	0.95	0.77
	ω_g	0.95	0.95	0.95	0.14
	$100 * \sigma_a$	0.01	0.01	0.10	0.22
	$100 * \sigma_g$	0.12	0.12	0.19	0.10
	χ^F	0.21	0.21	0.79	0.79
	χ^I	0.21	-	0.21	0.21
	a	0.2974			
			Second moments		
	Data		Model		
$\sigma(Y^F)$	1.01	0.87	0.85	1.57	2.03
$\sigma(C^F)/\sigma(Y^F)$	1.53	1.09	1.09	0.98	0.70
$\sigma(I^F)/\sigma(Y^F)$	3.70	7.01	6.74	6.80	7.27
$\sigma(TBY^F)/\sigma(Y^F)$	0.85	2.02	1.97	1.90	1.98
$\rho(Y^F)$	0.83	0.96	0.96	0.96	0.95
$\rho(C^F, Y^F)$	0.85	0.97	0.97	0.94	0.97
$\rho(I^F, Y^F)$	0.66	0.36	0.38	0.38	0.30
$\rho(TBY^F, Y^F)$	-0.36	-0.24	-0.24	-0.21	-0.08
$\sigma(h^A)/\sigma(Y^F)$	1.70	0.20	0.23	0.32	0.44
$\rho(h^A, Y^F)$	0.45	0.76	0.71	0.76	0.88
$\sigma(h^F)/\sigma(Y^F)$	1.76	0.24	0.21	0.36	0.60
$\sigma(h^I)/\sigma(Y^F)$	3.06	0.13	0.46	0.42	0.68
$\rho(h^F, Y^F)$	0.38	0.80	0.82	0.77	0.98
$\rho(h^I, Y^F)$	0.39	-0.18	0.30	-0.22	-0.52
$\rho(h^I, h^F)$	0.14	-0.11	0.58	-0.002	0.90

Note: In our benchmark model, we assume that $\omega_a = \omega_g$ and $\chi^F = \chi^I$. In Case 1, there is only an adjustment cost in the formal sector. In Case 2, we assume that $\omega_a = \omega_g$ but $\chi^F \neq \chi^I$. In Case 3, we assume that $\omega_a \neq \omega_g$ and $\chi^F \neq \chi^I$.

Table 3.11: Business Cycle Moments: Turkey

		Benchmark	Case 1	Case 2	Case 3
			Estimated Parameters		
	ω_a	0.68	0.68	0.95	0.95
	ω_g	0.68	0.68	0.95	0.05
	$100 * \sigma_a$	0.14	0.14	0.10	0.22
	$100 * \sigma_g$	0.21	0.21	0.40	0.16
	χ^F	0.79	0.79	0.99	0.99
	χ^I	0.79	-	0.79	0.79
	a	0.2640			
				Second moments	
	Data		Model		
$\sigma(Y^F)$	3.15	2.05	1.97	2.95	3.25
$\sigma(C^F)/\sigma(Y^F)$	1.01	1.11	1.12	1.34	0.78
$\sigma(I^F)/\sigma(Y^F)$	2.69	6.78	6.40	6.50	6.71
$\sigma(TBY^F)/\sigma(Y^F)$	0.52	1.99	1.94	1.98	1.80
$\rho(Y^F)$	0.81	0.96	0.96	0.96	0.96
$\rho(C^F, Y^F)$	0.88	0.88	0.85	0.93	0.95
$\rho(I^F, Y^F)$	0.92	0.35	0.38	0.40	0.33
$\rho(TBY^F, Y^F)$	-0.36	-0.20	-0.21	-0.32	-0.11
$\sigma(h^A)/\sigma(Y^F)$	0.91	0.25	0.30	0.15	0.28
$\rho(h^A, Y^F)$	0.17	0.78	0.76	0.65	0.27
$\sigma(h^F)/\sigma(Y^F)$	1.13	0.51	0.50	0.29	0.67
$\sigma(h^I)/\sigma(Y^F)$	1.07	0.05	0.22	0.06	0.71
$\rho(h^F, Y^F)$	0.41	0.83	0.81	0.74	0.99
$\rho(h^I, Y^F)$	-0.33	-0.55	0.23	-0.43	-0.70
$\rho(h^I, h^F)$	0.33	-0.76	0.38	-0.44	0.96

Note: In our benchmark model, we assume that $\omega_a = \omega_g$ and $\chi^F = \chi^I$. In Case 1, there is only an adjustment cost in the formal sector. In Case 2, we assume that $\omega_a = \omega_g$ but $\chi^F \neq \chi^I$. In Case 3, we assume that $\omega_a \neq \omega_g$ and $\chi^F \neq \chi^I$.

more volatile if the value of pass-through of shocks are lower (6) the model with informal sector has a powerful mechanism for shocks to replicate the labour market variables in these economies compared to earlier studies in the literature. We can conclude that the level of employment protection is important as it has a significant effect on the business cycle fluctuations in these economies as well as the standard deviation of shocks and pass-through of the shocks. Therefore, a model with informal sector and LACs can explain the differences between EMEs as well as estimating these parameter values help us to explore whether the informal employment acts or does not act as as a buffer in the formal sector.

In Appendix 3.C, we present cross correlation between informal employment and formal output from the benchmark model in EMEs. The model matches well the lagging (leading) property of this correlation as in data for Mexico and Turkey (Colombia and South Africa). We lastly investigate how the correlation between informal employment and formal employment (corr (hI,hF)) and the standard deviation between informal employment with formal output (std (hI,yF)) change when the standard deviation of permanent shocks (σ) and the labour adjustment costs in the formal sector (χ_F) vary. Then, in second row at the same figure, we examine how the correlation between informal employment and formal output (corr (hI,yF)) with LACs (first figure) and without LACs (second figure) change when the standard deviation of permanent shocks (σ) and the pass-through of the permanent shocks change (ω_g). Consistent with our empirical findings, the standard deviation of shocks has impact on these facts compared to the LACs and the pass-through of shocks (see Appendix 3.C).

3.6 Conclusion

Despite the existence of a large informal labour market in EMEs, it has received less attention by many researchers who are interested in business cycles in these economies. On the empirical side, we find that it is countercyclical in Mexico, Colombia, and Turkey but pro-cyclical in South Africa. In addition, it is negatively correlated with formal employment in Mexico but positively correlated in Colombia, South Africa and Turkey. Also, it is more volatile than formal employment in Mexico and South Africa, but it is less than in that of Colombia and Turkey. Moreover, we explore that the data confirms the buffer effect for Mexico, South Africa and Turkey regarding volatilities as we find that informal employment is more volatile than formal employment. Furthermore, we explore that informal employment is counter-cyclical and formal employment is pro-cyclical in Mexico, Colombia and Turkey which confirms that informal sector acts as a buffer in these economies as well.

From a theoretical perspective, we introduce an informal labour market into a standard business cycle model of a small open economy. We assume that households choose how much labour to allocate to each market and shocks are imperfectly transmitted from the formal to the informal sector. We then introduce labour adjustment costs into the model as employment protection in EMEs which differ among these economies. We claim that the differences in the degree of employment protection among countries can explain the differences in data moments between EMEs. Hence, we specifically focus on the role of LACs, the pass-through of shocks, and the standard deviation of shocks. We find that the model with informal sector and LACs generates satisfactorily key stylized facts in the labour market and the size of the shocks are lower compared to earlier studies in the literature. Therefore, our model acts as powerful propagation mechanism for shocks. In addition, the size of LACs and shocks are important for the buffer effect as well as the pass-through of the shocks. Therefore, researchers should focus on the estimation of these parameter values across countries as well as labour market regulations to have a good understanding labour market properties of business cycle fluctuations in EMEs.

3.A Appendix: Additional Business Cycles

Table 3.12: Mexico (2000-2010)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(h_1^i,i)$	$\rho(h_2^i,i)$	$\rho(h_3^i,i)$	$\rho(h_4^i,i)$	$\rho(h_5^i,i)$	$\rho(h_6^i,i)$
h	0.86	0.39	0.58	0.67	0.53	0.59	-0.33	0.16	0.01
h_1^f	0.77	0.39	0.73	0.13	0.03	0.21	-0.15	-0.22	-0.32
h_2^f	0.75	0.38	0.74	0.42	0.19	0.60	-0.21	-0.10	-0.17
h_3^f	0.80	0.40	0.59	0.69	0.68	0.40	-0.35	0.24	0.03
h_4^f	1.47	0.74	0.56	0.76	0.68	0.57	-0.74	0.21	-0.10
h_5^f	1.12	0.56	0.86	0.40	0.24	0.47	-0.31	-0.43	-0.47
h_6^f	1.23	0.62	0.79	0.49	0.39	0.44	-0.51	-0.23	-0.47
h_1^i	1.42	0.71	0.23	1	0.91	0.73	-0.36	0.54	0.40
h_2^i	1.99	0.99	0.11	0.91	1	0.39	-0.37	0.61	0.40
h_3^i	1.34	0.67	0.33	0.73	0.39	1	-0.20	0.21	0.25
h_4^i	2.05	1.02	-0.26	-0.36	-0.37	-0.20	1	-0.04	0.36
h_5^i	2.61	1.30	-0.44	0.54	0.61	0.21	-0.04	1	0.83
h_6^i	1.78	0.89	-0.47	0.40	0.40	0.25	0.36	0.83	1

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of X. $\rho(x,y)$ denotes the correlation between the cyclical components of x and y. h stands for quarterly data on total employment. We have six informality measures: h_1^i (employed in micro business), h_2^i (employed in micro business without fixed establishment), h_3^i (employed in micro business with fixed establishment), h_4^i (employed and remunerated without benefits provided by labour legislation), h_5^i (self-employed) and h_6^i (workers in the informal sector-employment in economic units not distinguished from households). h_1^f, h_2^f, h_3^f, h_4^f, h_5^f and h_6^f refer to the residual when each of the six series on informal employment are subtracted from total employment. The series are logged first except for the ratio NX and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

FIGURE 3.1: Mexico (2000-2010)

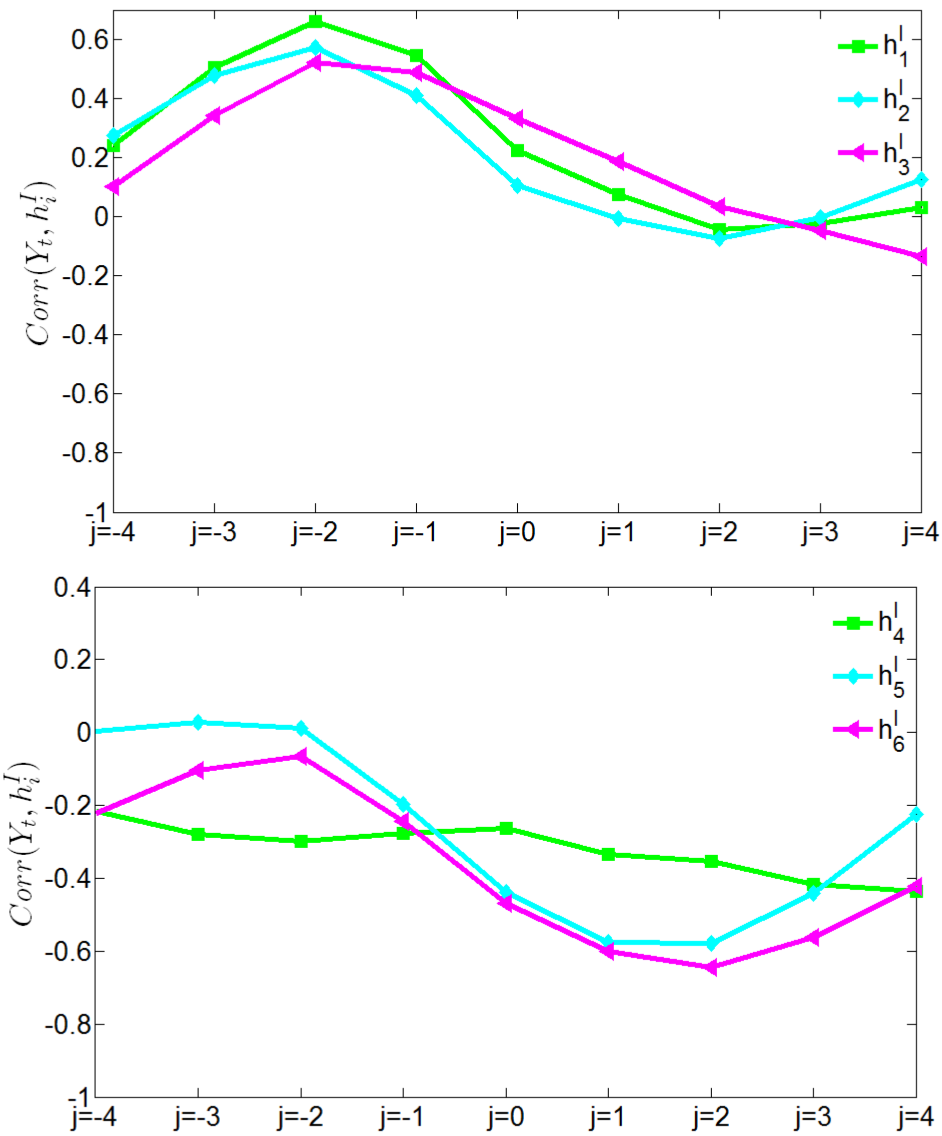


Table 3.13: Colombia (2007-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(h_1^i,i)$	$\rho(h_2^i,i)$
Th	1.95	1.67	0.20	0.78	0.48
h	1.58	1.35	0.40	0.80	0.53
h_1^f	1.96	1.68	0.66	0.28	0.17
h_2^f	7.36	6.30	0.21	0.15	0.66
h_1^i	1.97	1.69	-0.01	1	0.67
h_2^i	2.31	1.97	-0.04	0.67	1

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of X. $\rho(x,y)$ denotes the correlation between the cyclical components of x and y. Th and h stand for quarterly data on total employment in national and total employment in 13 cities and metropolitan areas, respectively. We have two informality measures for h: h_1^i (employed according to company size up to 5 workers) and h_2^i (self employment). h_1^f, and h_2^f refer to the residual when each of the three series on informal employment are subtracted from total employment. The series are logged first except for the ratio NX and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

Figure 3.2: Colombia (2007-2017)

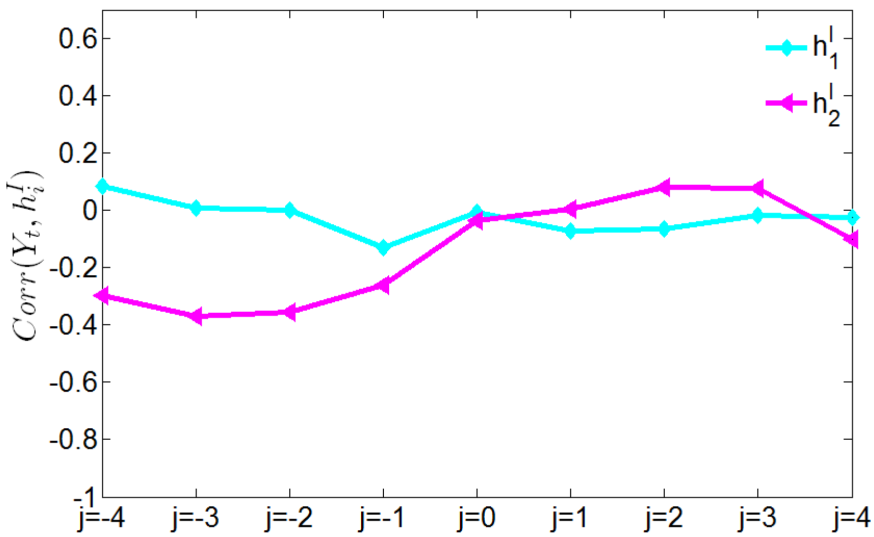


Table 3.14: South Africa (2008-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(h_1^i,i)$
h	1.74	1.70	0.45	0.48
h_1^f	1.81	1.76	0.38	0.14
h_1^i	3.17	3.06	0.39	1

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of X. $\rho(x,y)$ denotes the correlation between the cyclical components of x and y. h stands for quarterly data on total employment. We have only one informality measure: h_1^i (in non-agricultural). h_1^f refer to the residual when each of the series on informal employment are subtracted from total employment. The series are logged first except for the ratio NX and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

Figure 3.3: South Africa (2008-2017)

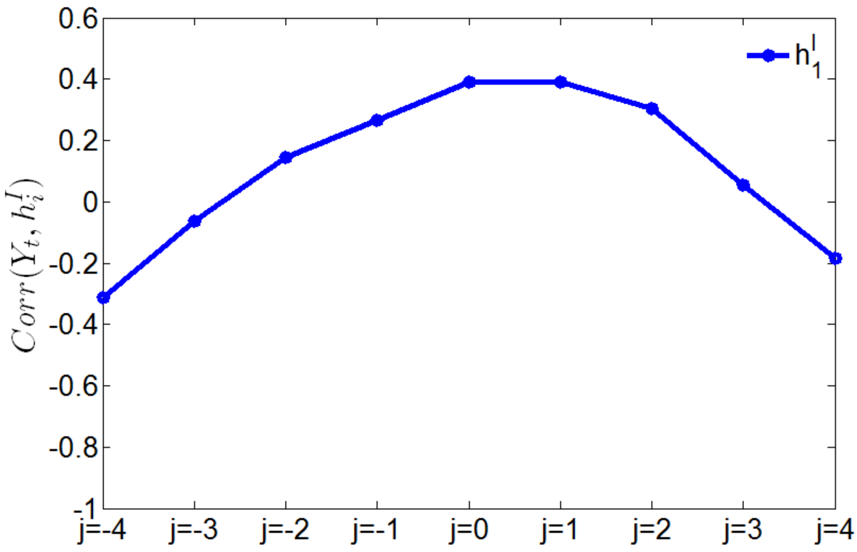
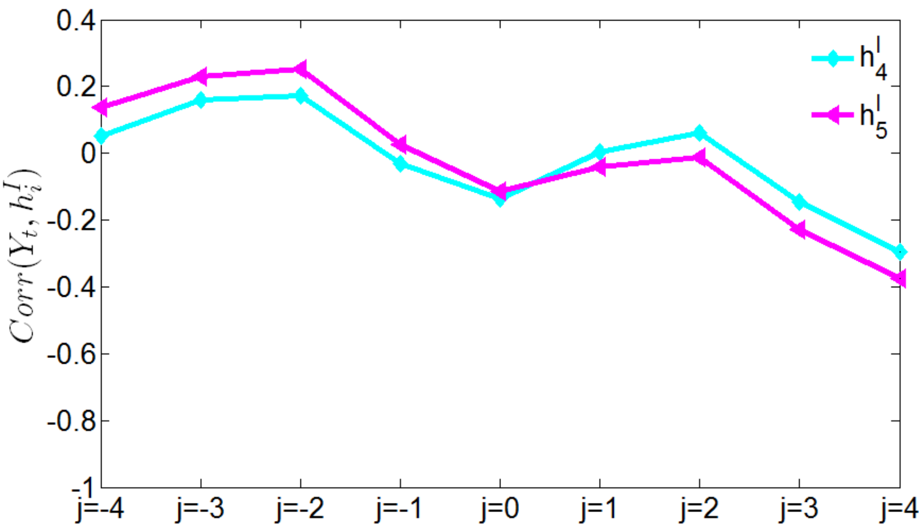


Table 3.15: Turkey (2005-2017)

Variable	σ_i	σ_i/σ_Y	$\rho(i,Y)$	$\rho(h_1^i,i)$	$\rho(h_2^i,i)$	$\rho(h_3^i,i)$
h	2.91	0.91	0.17	0.66	0.34	0.92
h_1^f	2.03	0.64	0.69	-0.15	-0.28	0.03
h_2^f	3.58	1.13	0.41	-0.06	0.16	0.18
h_3^f	3.17	1.00	0.26	-0.11	-0.15	0.04
h_1^i	4.68	1.47	0.01	1	0.33	0.74
h_2^i	3.40	1.07	-0.33	0.48	1	0.52
h_3^i	6.16	1.94	-0.11	0.96	0.96	1

Note: $\sigma(x)$ denotes the standard deviation of the cyclical component of X. $\rho(x,y)$ denotes the correlation between the cyclical components of x and y. h stands for quarterly data on total employment. We have three measure of informality (Employed persons by social security registration): h_1^i (in non-agriculture), h_2^i (self employment), and h_3^i (employed according to company size up to 10 workers). h_1^f, h_2^f, and h_3^f refer to the residual when each of the six series on informal employment are subtracted from total employment. The series are logged first except for the ratio NX and then filtered using the Hodrick-Prescott filter with a smoothing parameter of 1600.

Figure 3.4: Turkey (2005-2017)



3.B Appendix: The Solution of Model

3.B.0.1 The consumer problem

The consumer's Lagrangian is

$$\mathcal{L} = E_0 \sum_{t=0}^{\infty} \beta^t \{ \frac{((a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} - \Gamma_{t-1}^F (h_t^A)^\kappa)^{1-\sigma} - 1}{1-\sigma} \tag{3.B.1}$$

$$+ \lambda_t[-D_t + (1-\tau^Y)(W_t h_t^F + r_t K_t^F) + p_t(z_t^I (K_t^I)^{\alpha_I} (\Gamma_t^I h_t^I)^{1-\alpha_I} - \Gamma_{t-1}^F \chi^I (\frac{h_t^I}{h_{t-1}^I} - 1)^2 h_t^I)$$

$$+ q_t D_{t+1} - C_t^F - p_t C_t^I - K_{t+1}^F + K_t^F(1-\delta^F) - p_t(K_{t+1}^I - K_t^I(1-\delta^I))]\}$$

where $h_t^A = h_t^F + h_t^I$.

The first orders conditions for C_t^F, C_t^F, h_t^F, h_t^I, D_{t+1}, K_{t+1}^F, K_{t+1}^I are:

$$\frac{\partial \mathcal{L}}{\partial C_t^F} = \beta^t \{((a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} - \Gamma_{t-1}^F (h_t^F + h_t^I)^\kappa)^{-\sigma} \tag{3.B.2}$$

$$(a(C_t^F)^e + (1-a)(C_t^I)^e)^{\frac{1}{e}-1} (a(C_t^F)^{e-1} - \lambda_t\}$$

$$\frac{\partial \mathcal{L}}{\partial C_t^I} = \beta^t \{((a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} - \Gamma_{t-1}^F (h_t^F + h_t^I)^\kappa)^{-\sigma} \tag{3.B.3}$$

$$(a(C_t^F)^e + (1-a)(C_t^I)^e)^{\frac{1}{e}-1} (1-a)(C_t^I)^{e-1} - \lambda_t p_t\}$$

$$\frac{\partial \mathcal{L}}{\partial h_t^F} = \beta^t \{((a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} - \Gamma_{t-1}^F (h_t^F + h_t^I)^\kappa)^{-\sigma} \tag{3.B.4}$$

$$(-)\Gamma_{t-1}^F \kappa (h_t^F + h_t^I)^{\kappa-1} + \lambda_t (1-\tau^Y) W_t\}$$

$$\frac{\partial \mathcal{L}}{\partial h_t^I} = \beta^t \{((a(C_t^F)^e + (1-a)(C_t^I)^e)^{1/e} - \Gamma_{t-1}^F (h_t^F + h_t^I)^\kappa)^{-\sigma} \tag{3.B.5}$$

$$(-)\Gamma_{t-1}^F \kappa (h_t^F + h_t^I)^{\kappa-1} + \lambda_t p_t (z_t^I (1-\alpha_I)(K_t^I)^{\alpha_I} (\Gamma_t^I)^{1-\alpha_I} (h_t^I)^{-\alpha_I}$$

$$- \Gamma_{t-1}^F \chi^I (\frac{h_t^I}{h_{t-1}^I} - 1)^2 - 2\Gamma_{t-1}^F \chi^I (\frac{h_t^I}{h_{t-1}^I} - 1) \frac{h_t^I}{h_{t-1}^I})\}$$

$$+ 2\beta^{t+1}\lambda_{t+1}p_{t+1}\Gamma_t^F\chi^I(\frac{h_{t+1}^I}{h_t^I} - 1)(\frac{h_{t+1}^I}{h_t^I})^2$$

$$\frac{\partial \mathcal{L}}{\partial D_{t+1}} = \beta^t\lambda_t q_t - \beta^{t+1}E_t\lambda_{t+1} \tag{3.B.6}$$

$$\frac{\partial \mathcal{L}}{\partial K_{t+1}^F} = \beta^t(-\lambda_t) + \beta^{t+1}E_t\{\lambda_{t+1}(r_{t+1}(1-\tau^Y) + (1-\delta^F))\} \tag{3.B.7}$$

$$\frac{\partial \mathcal{L}}{\partial K_{t+1}^I} = \beta^t\lambda_t(-p_t) + \beta^{t+1}E_t\{\lambda_{t+1}p_{t+1}(z_t^I\alpha_I(K_{t+1})^{\alpha_I-1}(\Gamma_{t+1}^I h_{t+1}^I)^{1-\alpha_I} + (1-\delta^I))\} \tag{3.B.8}$$

3.B.0.2 The formal firm problem

This problem is

$$\max z_t^F(K_t^F)^{\alpha_F}(\Gamma_t^F h_t^F)^{1-\alpha_F} - \Gamma_{t-1}^F\chi^F(\frac{h_t^F}{h_{t-1}^F} - 1)^2 h_t^F - (1+\tau^N)W_t h_t^F - r_t K_t^F \tag{3.B.9}$$

with F.O.C (K_t^F, h_t^F)

$$r_t = z_t^F\alpha_F(K_t^F)^{\alpha_F-1}(\Gamma_t^F h_t^F)^{1-\alpha_F} \tag{3.B.10}$$

$$W_t(1+\tau^N) = z_t^F(K_t^F)^{\alpha_F}(\Gamma_t^F)^{1-\alpha_F}(1-\alpha_F)(h_t^F)^{-\alpha_F} \tag{3.B.11}$$

$$- \Gamma_{t-1}^F\chi^F(\frac{h_t^F}{h_{t-1}^F} - 1)^2 - 2\Gamma_{t-1}^F\chi^F(\frac{h_t^F}{h_{t-1}^F} - 1)\frac{h_t^F}{h_{t-1}^F}$$

$$+ E_t(2\beta\Gamma_t^F\chi^F(\frac{h_{t+1}^F}{h_t^F} - 1)(\frac{h_{t+1}^F}{h_t^F})^2)$$

Note that we assume that the initial difference between Γ_0^I and Γ_0^F is pinned down by γ given that Γ_0^I=γ Γ_0^F. Hence, $\frac{\Gamma_0^F}{\Gamma_0^I} = \frac{1}{\gamma}$. Also, $g_1^I = (g_0^I)^{1-\omega_g}(g_1^F)^{\omega_g}$ and $g_0^I = \mu$. Then we find,

$$\frac{\Gamma_1^F}{\Gamma_1^I} = \frac{1}{\gamma}(\frac{g_1^F}{\mu})^{1-\omega_g} \tag{3.B.12}$$

Remember in the long run we assume that

$$\frac{\Gamma_t^F}{\Gamma_{t-1}^F} = \frac{\Gamma_t^I}{\Gamma_{t-1}^I} = \mu \tag{3.B.13}$$

which allow us to compute a balanced growth path equilibrium.

3.B.0.3 Normalized equations

We have a balanced growth path in this model. Hence, we need to normalize the model. We define lower case variables

$$x_t = \frac{X_t}{\Gamma^F_{t-1}} \tag{3.B.14}$$

We name the ratio of growth trend across sectors as

$$\widetilde{g}_t \equiv \frac{\Gamma^I_t}{\Gamma^F_t} \tag{3.B.15}$$

We derive $\widetilde{g}_t$ as follows:

$$g^I_t \equiv \frac{\Gamma^I_t}{\Gamma^I_{t-1}} = (g^I_{t-1})^{1-\omega_g}(g^F_t)^{\omega_g} \tag{3.B.16}$$

$$\Gamma^I_t = \Gamma^I_{t-1}(g^I_{t-1})^{1-\omega_g}(g^F_t)^{\omega_g}$$

$$\frac{\Gamma^I_t}{\Gamma^F_t} = \frac{\Gamma^I_{t-1}}{\Gamma^F_t}(g^I_{t-1})^{1-\omega_g}(g^F_t)^{\omega_g}$$

$$\widetilde{g}_t \equiv \frac{\Gamma^I_t}{\Gamma^F_t} = \frac{\Gamma^I_{t-1}}{g^F_t\Gamma^F_{t-1}}(g^I_{t-1})^{1-\omega_g}(g^F_t)^{\omega_g}$$

$$\widetilde{g}_t = \tilde{g}_{t-1}(\frac{g^I_{t-1}}{g^F_t})^{1-\omega_g}$$

Here is the stationary system of equations:

$$c^A_t = (a(c^F_t)^e + (1-a)(c^I_t)^e)^{1/e} \tag{3.B.17}$$

$$-q_t d_{t+1} g^F_t + c^F_t + p_t c^I_t + i^F_t + p_t i^I_t = -d_t + (w_t h^F_t + r_t k^F_t)(1-\tau^Y) + p_t y^I_t \tag{3.B.18}$$

$$y^I_t = z^I_t (k^I_t)^{\alpha_I}(g^I_t \tilde{g}_{t-1} h^I_t)^{1-\alpha_I} - \chi^I(\frac{h^I_t}{h^I_{t-1}} - 1)^2 h^I_t \tag{3.B.19}$$

$$k^F_{t+1} g^F_t = i^F_t + (1-\delta^F)k^F_t \tag{3.B.20}$$

$$k^I_{t+1} g^F_t = i^I_t + (1-\delta^I)k^I_t \tag{3.B.21}$$

$$k_t = p_t k_t^I + k_t^F \tag{3.B.22}$$

$$y_t^F = z_t^F (k_t^F)^{\alpha_F} (g_t^F)^{1-\alpha_F} (h_t^F)^{1-\alpha_F} - \chi^F (\frac{h_t^F}{h_{t-1}^F} - 1)^2 h_t^F \tag{3.B.23}$$

$$r_t = z_t^F \alpha_F (K_t^F)^{\alpha_F - 1} (g_t^F h_t^F)^{1-\alpha_F} \tag{3.B.24}$$

$$W_t(1+\tau^N) = z_t^F (K_t^F)^{\alpha_F} (g_t^F)^{1-\alpha_F} (1-\alpha_F)(h_t^F)^{-\alpha_F} - \chi^F (\frac{h_t^F}{h_{t-1}^F} - 1)^2 \tag{3.B.25}$$

$$- 2\chi^F (\frac{h_t^F}{h_{t-1}^F} - 1)\frac{h_t^F}{h_{t-1}^F} + 2\beta g_t^F \chi^F (\frac{h_{t+1}^F}{h_t^F} - 1)(\frac{h_{t+1}^F}{h_t^F})^2$$

$$\tau^N w_t h_t^F + (w_t h_t^F + r_t k_t^F)\tau^Y = g_t \tag{3.B.26}$$

$$1/q_t = R + \widetilde{\psi}[\exp(d_{t+1} - d) - 1] \tag{3.B.27}$$

$$ln(z_{t+1}^F) = \rho_z ln(z_t^F) + \varepsilon_{t+1}^z \tag{3.B.28}$$

$$z_t^I = (z_{t-1}^I)^{1-\omega_z} (\gamma z_t^F)^{\omega_z}$$

$$ln(g_{t+1}^F/\mu) = \rho_g ln(g_t^F/\mu) + \varepsilon_{t+1}^g \tag{3.B.29}$$

$$g_t^I = (g_{t-1}^I)^{1-\omega_g} (g_t^F)^{\omega_g}$$

$$y_t^I = c_t^I + i_t^I \tag{3.B.30}$$

$$nxy_t = \frac{y_t^F - c_t^F - i_t^F - g_t}{y_t^F} \tag{3.B.31}$$

$$\lambda_t = (c_t^A - (h_t^F + h_t^I)^\kappa)^{-\sigma} (a(c_t^F)^e + (1-a)(c_t^I)^e)^{\frac{1}{e}-1} a(c_t^F)^{e-1} \tag{3.B.32}$$

$$\lambda_t p_t = (c_t^A - (h_t^F + h_t^I)^\kappa)^{-\sigma} (a(c_t^F)^e + (1-a)(c_t^I)^e)^{\frac{1}{e}-1} (1-a)(c_t^I)^{e-1} \tag{3.B.33}$$

$$\kappa(h_t^F + h_t^I)^{\kappa-1}(c_t^A - (h_t^F + h_t^I)^{\kappa})^{-\sigma} = \lambda_t(1-\tau^Y)w_t \tag{3.B.34}$$

$$\kappa(h_t^F + h_t^I)^{\kappa-1}(c_t^A - (h_t^F + h_t^I)^{\kappa})^{-\sigma} = \lambda_t p_t (z_t^I(1-\alpha_I)(k_t^I)^{\alpha_I}(g_t^F\tilde{g}_t)^{1-\alpha_I}(h_t^I)^{-\alpha_I} \tag{3.B.35}$$

$$-\chi^I(\frac{h_t^I}{h_{t-1}^I} - 1)^2 - 2\chi^I(\frac{h_t^I}{h_{t-1}^I} - 1)\frac{h_t^I}{h_{t-1}^I}) + 2\beta\lambda_{t+1}p_{t+1}g_t^F\chi^I(\frac{h_{t+1}^I}{h_t^I} - 1)(\frac{h_{t+1}^I}{h_t^I})^2$$

$$\lambda_t q_t = \beta(g_t^F)^{-\sigma} - E_t\lambda_{t+1} \tag{3.B.36}$$

$$\lambda_t = \beta(g_t^F)^{-\sigma}E_t\{\lambda_{t+1}(r_{t+1}(1-\tau^Y) + (1-\delta^F))\} \tag{3.B.37}$$

$$\lambda_t p_t = \beta(g_t^F)^{-\sigma}E_t\{\lambda_{t+1}(p_{t+1}(z_t^I\alpha_I(K_{t+1})^{\alpha_I-1}(g_{t+1}^I\tilde{g}_t h_{t+1}^I)^{1-\alpha_I} + (1-\delta^I))\} \tag{3.B.38}$$

$$\tilde{g} = \tilde{g}_{t-1}(\frac{g_{t-1}^I}{g_t^F})^{1-\omega_g} \tag{3.B.39}$$

$$h_t = h_t^F + h_t^I \tag{3.B.40}$$

$$y_t = y_t^F + p_t y_t^I \tag{3.B.41}$$

3.B.0.4 Steady State

The system that defines the non-stochastic steady state of the model is given by the following set of equations:

$$-\beta\mu^{1-\sigma}d + c^F + pc^I + i^F + pi^I = -d + (wh^F + rk^F)(1-\tau^Y) + py^I \tag{3.B.42}$$

$$y^I = \gamma(k^I)^{\alpha_I}(\mu\tilde{g}h^I)^{1-\alpha_I} \tag{3.B.43}$$

$$i^F = k^F\mu - (1-\delta^F)k^F \tag{3.B.44}$$

$$i^I = k^I\mu - (1-\delta^I)k^I \tag{3.B.45}$$

$$k = pk^I + k^F \tag{3.B.46}$$

$$y^F = (k^F)^{\alpha_F}(\mu h^F)^{1-\alpha_F} \tag{3.B.47}$$

$$r = \alpha_F(k^F)^{\alpha_F-1}(\mu h^F)^{1-\alpha_F} \tag{3.B.48}$$

$$w(1+\tau^N) = (k^F)^{\alpha_F}(\mu)^{1-\alpha_F}(1-\alpha_F)(h^F)^{-\alpha_F} \tag{3.B.49}$$

$$\tau^N wh^F + (wh^F + rk^F)\tau^Y = g \tag{3.B.50}$$

$$y^I = c^I + i^I \tag{3.B.51}$$

$$nxy = \frac{y^F - c^F - i^F - g}{y^F} \tag{3.B.52}$$

$$p = \frac{1-a}{a}(\frac{c^I}{c^F})^{e-1} \tag{3.B.53}$$

$$\kappa(h^F + h^I)^{\kappa-1} = (a(c^F)^e + (1-a)(c^I)^e)^{\frac{1}{e}-1}a(c^F)^{e-1}(1-\tau^Y)w \tag{3.B.54}$$

$$\kappa(h^F + h^I)^{\kappa-1} = (a(c^F)^e + (1-a)(c^I)^e)^{\frac{1}{e}-1}a(c^F)^{e-1} \tag{3.B.55}$$

$$p\gamma(1-\alpha_I)(k^I)^{\alpha_I}(\mu\tilde{g})^{1-\alpha_I}(h^I)^{-\alpha_I}$$

$$1 = \beta(\mu)^{-\sigma}(\gamma\alpha_I(k^I)^{\alpha_I-1}(\tilde{g}\mu h^I)^{1-\alpha_I} + (1-\delta^I)) \tag{3.B.56}$$

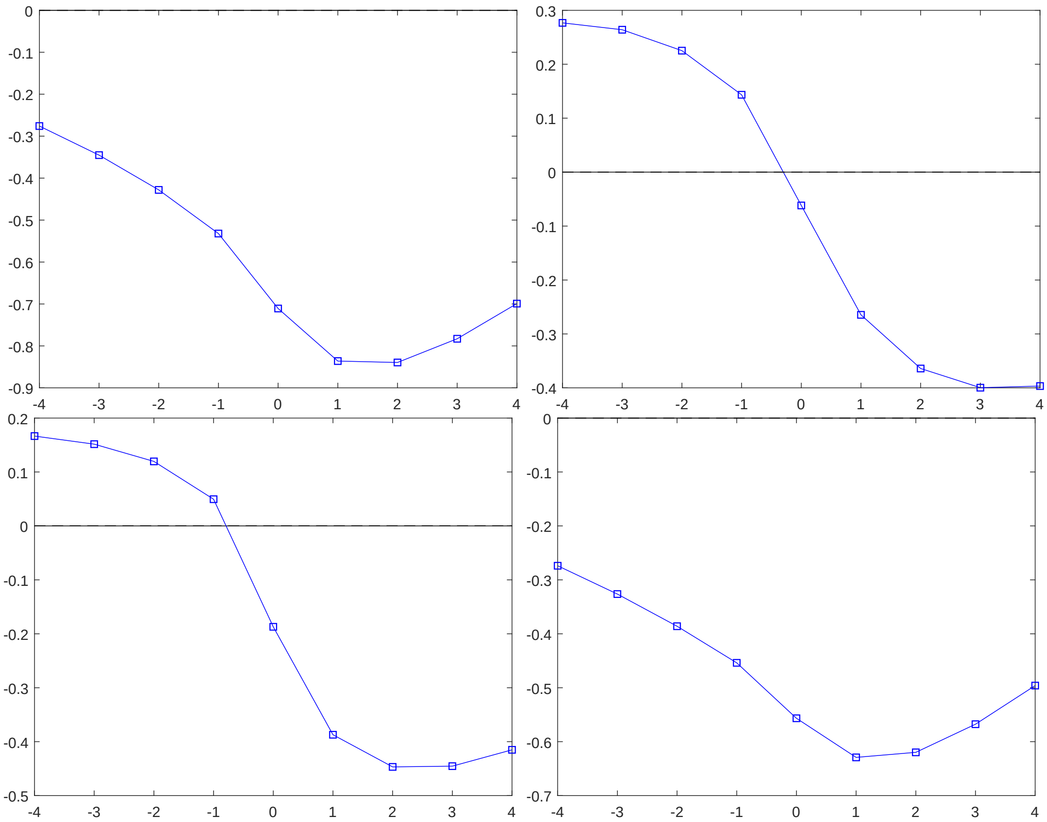
We use the share of informal employment to pin down the value of the parameter a (share of formal goods in aggregate consumption) for each countries. The last equation is added to pin down the steady state value of debt.

$$\frac{h^I}{h^I + h^F} \tag{3.B.57}$$

$$\frac{d}{y^F} = 0.1 \tag{3.B.58}$$

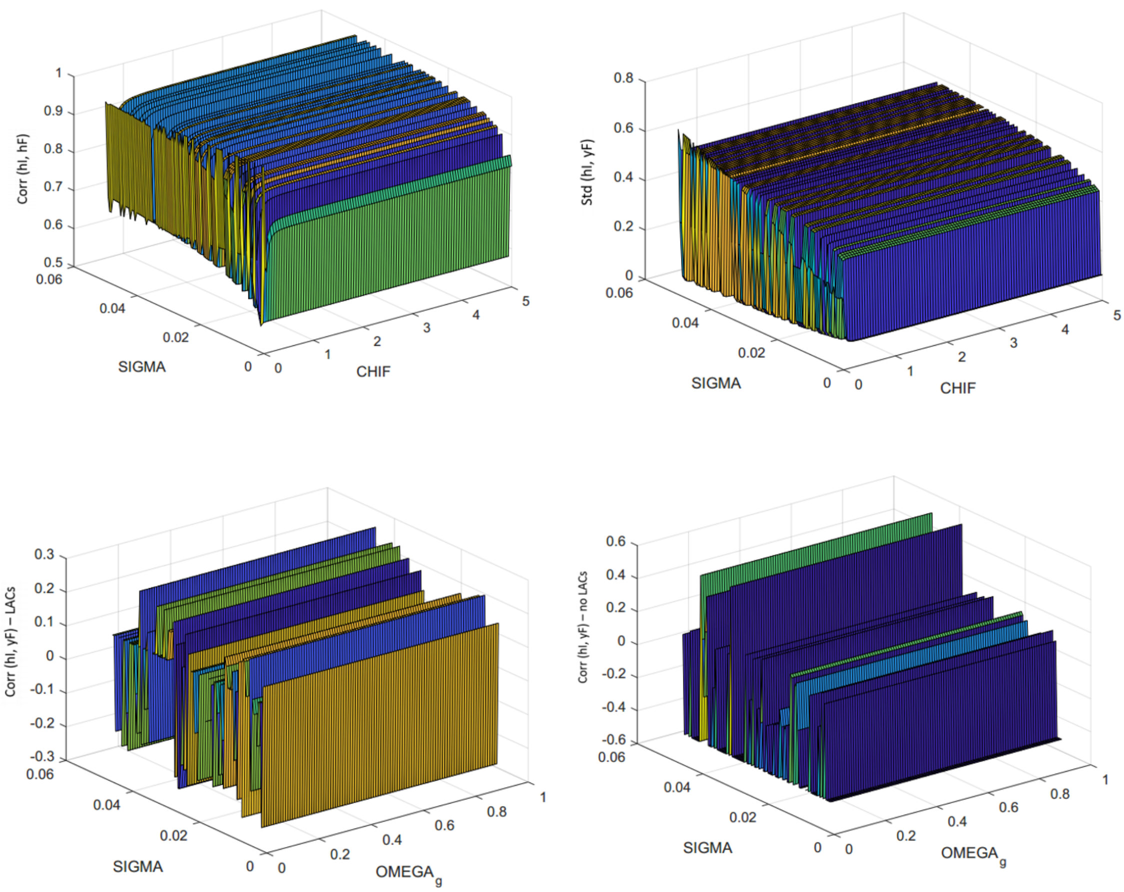
3.C Appendix: Additional Figures

FIGURE 3.5: Cross Correlation Between Output and Informal Employment: Benchmark Model



Note: This figure shows cross correlation between output and informal employment from the benchmark model. From left to the right: Mexico and Colombia (first row), South Africa and Turkey (second row).

FIGURE 3.6: The Changes in Some Moments Based on the Changes in Parameter Values



Note: In this figure, the first row shows how the correlation between informal employment and formal employment (corr (hI,hF)) and the standard deviation between informal employment with formal output (std (hI,yF)) change when the standard deviation of permanent shocks (σ) and the labour adjustment costs in the formal sector (CHIF) vary. The second row shows how the correlation between informal employment and formal output (corr (hI,yF)) change when the standard deviation of permanent shocks (σ) and the pass-through of the permanent shocks (ω_g) change. The first figure shows the results when there is a labour adjustment cost and second figure shows the results when there no labour adjustment costs.

Conclusion

The first study explores labour market fluctuations in the business cycles of EMEs and compares these results with findings from the US for the period of 1970-2013. In the data we observe that the behaviour of labour market variables are not uniform across countries. Compared to the US, we find that on average real wages and productivity are very volatile but less volatile in terms of the quantities in EMEs. Then we show how far the various real business cycle models (RBC) with permanent and transitory productivity shocks could take us in explaining the labour market fluctuations of business cycles in these economies, rather than to show a model that incorporates all extensions of the RBC could produce all labour market facts. The results show that the standard RBC model does reasonably well in matching the relative volatility of the hours worked in EMEs; however, it fails to account for the rest of the relevant moments in our analysis. We also find that the model with capacity utilization, investment adjustment costs and indivisible labour improved the capability of the RBC model. Lastly, we investigate the cyclical behaviour of the labour wedge. We find that the labour wedge is more volatile in the emerging countries than in the US and the fluctuations in the labour wedge are mostly driven by fluctuations in the gap between the real wage and the MRS in both the EMEs and the US. The contribution of this chapter is to provide a useful guide for researchers about labour market properties of business cycle fluctuations in EMEs and where to introduce frictions to make the business cycle models more consistent with the data for these economies.

The second study focuses on the responses of hours and real GDP to technology and non-technology shocks in EMEs. In the standard business cycle models hours are stationary. However, in the data, per capita hours worked are non-stationary in these economies. Hence, these models could not match the response of hours and GDP to technology and non-technology shocks in EMEs. We first provide empirical evidence on the impact of these shocks on hours and GDP in Difference Structural VAR (DSVAR) model and then propose a DSGE model incorporating labour supply (LS) shocks, while preserving balance growth path. The identifying assumption imposed in the DSVAR and the DSGE model are consistent. That is, only LS shocks can produce long-run changes in hours worked as we observe discernibly the variations in labour supply patterns in emerging countries. Then, we test the DSGE model against the DSVAR results using Indirect Inference. We find that hours worked increases after a positive LS shocks and this model indirectly replicate the impulse responses of hours worked and real GDP to both shocks in EMEs but it is not statistically significant in the long run. The contribution of this chapter is to provide a useful insight about economic factors behind the fluctuations in hours worked and to show how DSGE models need to be modified to match certain aspects of EMEs. We show the importance of the role of LS shocks for EMEs fluctuations.

In the last paper, we focus on the role of informal employment and show how it shapes the aggregate dynamics over the business cycles in EMEs. We find that informal employment is countercyclical in Mexico, Colombia, and Turkey but pro-cyclical in South Africa. In addition, it is negatively correlated with formal employment in Mexico but positively correlated in Colombia, South Africa and Turkey. From a theoretical perspective, we introduce an informal labour market into a standard business cycle model of a small open economy with stationary and trend shocks to total factor productivity as well as labour adjustment costs (LACs) as employment protection in EMEs. We then explore to what extent the informal sector acts as a buffer for the formal sector for these economies. We find that this model generates satisfactorily key stylized facts in the labour market and the size of the shocks in this model is lower compared to earlier studies in the literature. Therefore, the features introduced in our model acts as powerful propagation mechanism for shocks. We also explore that informal employment acts as a buffer in the formal sector regarding correlations as we find that, in the model, informal employment is countercyclical and formal employment is pro-cyclical which supports to the findings from the data except for South Africa. Regarding volatilities, informal employment does not act as a buffer because the formal employment is more volatile than the informal employment in the model which contrasts with the evidence in the data for these economies except for Colombia. Lastly, we observe that the size of LACs and shocks are important to explain the differences in the data moments between EMEs. This chapter hence contributes to the literature by motivating the empirical research towards the estimation of these parameter values for each EMEs and that researchers should focus more on labour market regulations to have a better understanding of labour market properties of business cycles in these economies.

In this section, we would also like to discuss the restrictive features of our methodology. These restrictions are imperfect competition, migration, births and deaths, household heterogeneities, the differing and evolving capital controls for the open economy model, the allocation of worker's time between renumerated work and training, central to many endogenous growth models, and the fact the most economies described may well not be in steady state or on a steady state growth path but are more likely in fact transition towards a steady state. These restrictions exist and might affect our results.

The first restriction is imperfect competition. The literature on equilibrium modelling of aggregate fluctuations has mainly assumed that firms are perfectly competitive. However, imperfect competition matters as it affects the way in which the economy responds to a great variety of shocks. Rotemberg and Woodford (1993) show that it affects the relationship between the marginal product of labour and the real wage. That is, it affects the relationship between output, the labour input and the wage. Lebow (2008) has also explained that there is an imperfect competition (either in goods or labour markets) which can help to explain the magnitude of business cycles. He mentions that imperfectly competitive firms keep prices more rigid in the face of demand shocks than do more competitive firms. Hence, output and employment adjust more when prices adjust less. In addition, the labour market in EMEs is not flexible. Since there is wage rigidity in these economies, market clearing does not fully work. The flexibility of wages matters because if there is a shock to productivity, it increases employment as well as wages if wages are flexible. However, if wages are not adjusted to the shock, that is fixed, the only adjustment happens on employment. Hence, we could develop a model with labour market frictions, such as wage rigidity. The rigidity in labour market might generate wage inflation that further explains the dynamics of thelabour market in these economies. Also, the labour market in EMEs is rigid mainly because of strict employment protection legislation and relatively high minimum wage. Many researchers have argued that institutional rigidities affect labor market variables in response to macroeconomic shocks, because of the imperfect adjustment of employment and real wage. Hence, introducing a minimum wage on business cycle models and adjustment to shocks would amplify output volatility and employment volatility in these economies (see Porter and Vitek (2008)'s work).

The second restriction is migration, births and deaths. Along with births and deaths, migration is one of the three demographic components of population change as it has had significant impacts on the demographic characteristics of the population in recent decades. The changes in population have been postulated as a cause of economic fluctuations. During downswings in the economy, a falling birth rate might be responsible for employment decline while during upswings in the economy an increasing birth rate might increase employment. Also, birth rate, age structure and other related demographic indicators can be determinant on the labour supply size in the long run as well as migration influences participation rates and reinforce the effects reported for participation variables. In addition, the amount of labour force participation influences economic growth. For example; labour force participation might be high because of low birth and death rates. It would increase population growth and then the need for goods and services would also increase. More jobs would then be available and the employment rate would also increase. In emerging market economies, birth rates are high so the young population is high. Hence, the workforce in these economies is higher compared to developed ones. Again, the size of the working age population depends on birth, death and migration and a change in the size of a working population would change the labour supply in the long-run.

The third restriction is household heterogeneities. Rotemberg and Woodford (2018) show that household heterogeneity is pervasive along many dimensions such as differences across households in terms of their age, education, occupation and income composition all matter for many of their key economic decisions. It is also relevant for macroeconomics. In particular, it matters for the quantitative study of economic fluctuations. However, in many dynamic models, we treat households or firms as a single representative agent. Since we ignore market frictions from these models, we should be skeptical about the model's ability to explain business cycles fluctuations. This would be good to show the separate actions of a large number of different households in macro models. Thus, incorporating household heterogeneity into models of business cycle explicitly might change our results as it entirely changes the transmission mechanism of the shock. For example; Jang, Sunakawa, and Yum (2018) find that the model with household heterogeneity can increase the degree to which aggregate hours vary over the business cycle and make average labour productivity less procyclical. Hence, household heterogeneities can be important for the amplification and propagation of macroeconomic shocks in these models.

The fourth restriction is the differing and evolving capital controls for the open economy model. Capital controls can be a useful policy tool to manage the macroeconomic and financial risks related to large fluctuations flows. Farhi and Werning (2012) also show that a counter-cyclical capital controls policy can play a role in macroeconomic stabilization in a small open economy with a fixed exchange rate. Hence, capital controls can mitigate the vulnerability of emerging economies to the external shocks. Many emerging market economies had decreased capital controls in the 1980s and 1990s in the spirit of liberalization and globalization (see Kose and Prasad (2004)'s work). However, Baba and Kokenyne (2011) mention that an increase in capital inflows into emerging market economies in the mid-2000s led some countries to introduce capital controls. They also explain that strong economic performance and relatively high interest rates in EMEs attracted capital inflows from advanced economies with low interest rates. However, it increases concerns over undue appreciation pressure on the currency, which reduces the competitiveness of the EME's export sector and increase risks the macroeconomic and financial stability. These concerns again lead countries to introduce controls on capital inflows. Moreover, with the recent surge in capital inflows to emerging market economies, Kitano (2011) explains that capital controls are seen as an important policy instrument to curtail the ensuing the boom and boost cycles. Therefore, Brazil, Thailand, South Korea, Taiwan have introduced capital controls after the crisis. In this study, he focuses on the effect of capital control policy on welfare based on the small open economy model with costly financial intermediaries.

The fifth restriction is the allocation of worker's time between renumerated work and training, central to many endogenous growth models. Endogenous growth models seek to explain changes in technology by analyzing the role of investment in research, training, and education by firms as they have learned from experience how to produce more efficiently. Workers also allocate time between investment in research and development (R&D)/human capital and market production for wages. This allocation is key to generating endogenous growth models. Comin and Gertler (2006) observe that adoption and R&D intensities vary endogenously over the cycle and that framework can generate the kind of pro-cyclical movements in productivity over the medium term. They find that their model does a reasonably good job in characterizing the key features of the medium term cycle. Hence, we can conclude that R&D and human capital allocation decisions are important for long-run growth and medium term cycles but they are probably less relevant for business cycle movements.

The last restriction is the fact the most economies described may well not be in steady state or on a steady state growth path but are more likely in fact transition towards a steady state. Along the balanced growth path, the big ratios such as investment-output, consumption-output, capital-output, and real wage-output are stable as output, consumption, investment, capital stock, and real wages grow at the same rate, and the real rates of return to capital and per capita hours worked are stationary. The steady state growth path may fit well the developed countries experience but this will not fit the experiences of emerging market economies very well as these economies are characterized by significant changes in long-run growth rates and not by countries with stable long-run growth rates. That is, stable growth may be a better explanation of developed economies than EMEs since these economies have experience with booms or crashes in their growth. However, the literature tends to show steady improvements over time in most emerging market countries since many EMEs have high population growth rates. Also, emerging economies catch up with their developed counterparts due to higher marginal rates of return on invested capital.

Lastly, we would like to discuss the selection of the countries analysed in this thesis. We chose countries based on the availability of data. Given the nature and topic of this thesis, our main variables are output, hours worked, wages and informal employment in emerging market economies. In many emerging markets, reliable data on macro variables is limited or nonexistent, especially for hours worked, wages and informal employment and there are a lot of missing observations. Hence, we had to reduce the time period for some countries and variables. Still, we have sufficient data to provide an accurate picture of business cycles in EMEs. In addition, we used annual data instead of quarterly data for the first and second chapter since hours worked data is available only with annual frequency from emerging countries. However, we worked with quarterly informal employment data for Mexico, Turkey, South Africa and Colombia in the last chapter. Unfortunately, we could not find informal employment data for other emerging market economies.

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