INVENTION AND RESISTANCE

FabLabs Against Proletarianization

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30 March 2018
68,672 words

Thesis submitted to the Universität Hamburg and the University of Kent in partial fulfilment for requirements for the degree of Doctor of Philosophy after following the Erasmus Mundus Doctoral Programme in Cultural and Global Criminology

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Invention and Resistance: FabLabs Against Proletarianization

The contemporary philosopher Bernard Stiegler has reopened the debate on the historically Marxist concept of proletarianization. Whereas Marx and Engels define the term as the continued expansion of an economic class that must sell their labour to the owners of the means of production, Stiegler argues that proletarianization is better understood as the gradual erosion of know-how (*savoir*). He attributes this erosion to a societal mismanagement of technological change. Starting from the premise that technological objects are material externalizations of capacities that previously inhered in the human, Stiegler asserts that we have systematically failed to compensate for these technological externalizations with the acquisition of new capacities, specifically those that would allow us to participate in technology's continuous evolution. As a consequence, this new technologically illiterate proletariat must constantly react to technological changes that are always developed elsewhere.

This thesis contributes to the debate on proletarianization by investigating a network of digital fabrication workshops called Fabrication Laboratories, or FabLabs. Part of the broader 'maker' movement, an international community of people who make their own things and electronics, FabLabs are committed to democratizing access to the means of digital fabrication. Unlike other community-based workshops or shared machine shops, their goal is to build a global network of local labs that share similar capacities. Similar to the free and open source software movement, the FabLabs promote decentralized organizational structures and horizontal hierarchies both within and between labs.

My aim is to investigate the extent to which the FabLabs can be considered sites of *de*-proletarianization. In so doing, I build on Stiegler's work to propose my own definition of proletarianization as a process that weakens our individual and collective abilities to pose and respond to political, social, and economic problems. This process has been driven by an acceleration in the rate of technological change that has not been matched with a commensurate cultivation and distribution of the capacities that would allow people to problematize and participate in the technological evolution of their societies. As a result, the problems we face as individuals, collectives, and as a species, are increasingly conditioned by technological artifacts that we grasp inadequately as users and consumers.

Based on an ethnographic study of grassroots labs in France, Germany, and Hungary, I argue that FabLabs have a significant de-proletarianizing potential because they encourage people to problematize the technological conditions of society and develop the capacities necessary to change those conditions. However, FabLabs have thus far had a minimal de-proletarianizing effect on the societies in which they operate, largely due to their limited, and relatively homogeneous, membership base. They have also struggled to apply their principles of decentralization and flat hierarchies to the political structuring of the labs themselves, thereby undermining the abilities of their members to pose problems that are not just technological, but political as well.

Underlying this investigation is an ontological framework that is capacities-based, pluralist, and non-anthropocentric. Inspired by the works of Gilles Deleuze and the object-oriented ontologist Levi Bryant, I argue that all beings, humans and nonhumans, are defined by their capacities to affect, to be affected, and to resist. This ontological framework allows me to develop different concepts of invention and resistance that are integral to both my theorization of proletarianization and my assessment of the FabLabs as sites of de-proletarianization.

Erfindung und Widerstand: FabLabs gegen Proletarisierung

Der zeitgenössische Philosoph Bernard Stiegler hat die Debatte über das historisch marxistische Konzept der Proletarisierung wiedereröffnet. Während Marx und Engels den Begriff der Proletarisierung als die kontinuierliche Expansion einer ökonomischen Klasse, die ihre Arbeitskraft an die Inhaber der Produktionsmittel verkaufen muss, definiert haben, argumentiert Stiegler, dass Proletarisierung besser als eine graduelle Erosion von Wissen (*savoir*) verstanden werden sollte. Stiegler schreibt diese Erosion dem gesellschaftlichen Missmanagement von technologischem Wandel zu. Stiegler geht von der Prämisse aus, dass technologische Objekte materielle Externalisierungen von vorher im Menschen innewohnenden Fähigkeiten sind. Jedoch betont der Philosoph, dass wir systematisch daran gescheitert sind, diese technologischen Externalisierungen durch die Aneignung von neuen Fähigkeiten zu kompensieren, die es uns ermöglichen, an der kontinuierlichen Entwicklung von Technologie zu partizipieren. Somit muss das technologisch ungebildete Proletariat konstant auf neue, sich stetig an anderen Orten entwickelnde technologische Veränderung reagieren.

Diese Arbeit trägt zu der Debatte um Proletarisierung bei, in dem sie ein Netzwerk von digitalen Fabrikations-Werkstätten, sogenannten „Fabrication Laboratories", oder FabLabs, untersucht. FabLabs sind Teil der größeren „Maker-Bewegung", einer internationalen Gemeinschaft von Menschen, die ihre eigenen Dinge und Elektronik herstellen. FabLabs haben sich der Demokratisierung des Zugangs zu digitalen Fabrikationsmitteln verschrieben. Im Unterschied zu anderen gemeinschaftlichen Werkstätten oder gemeinsamen Werkräumen ist das Ziel von FabLabs, ein globales Netzwerk von lokalen Räumen zu erschaffen, welche ähnliche Fähigkeiten teilen. Ähnlich der freien und „Open-Source-Software-Bewegung", fördern die FabLabs dezentrale Organisationsstrukturen und horizontale Hierarchien innerhalb und zwischen den Labs.

Mein Ziel ist es zu untersuchen, inwieweit man die FabLabs als Räume von *De-Proletarisierung* verstehen kann. Hierbei stütze ich mich auf Stieglers Arbeit, um eine eigene Definition von Proletarisierung vorzuschlagen. Proletarisierung verstehe ich hier als Prozess, der unsere individuellen und kollektiven Fähigkeiten schwächt, um Probleme sozialer, ökonomischer oder politischer Natur zu formulieren und auf diese Antworten zu finden. Dieser Prozess wurde durch eine Beschleunigung von technologischem Wandels angetrieben, mit dem keine entsprechende Kultivierung und Verteilung von technologischen Fähigkeiten einherging, die es den Menschen ermöglicht hätte, die technologische Entwicklung ihrer Gesellschaft zu problematisieren und an dieser teilzunehmen. Als Resultat dessen sind die Probleme, mit denen wir als Individuen, als Kollektiv und als Spezies konfrontiert sind, stetig stärker von technologischen Artefakten geprägt, die wir nur ungenügend als Nutzer und Konsumenten erfassen können.

Basierend auf ethnographischen Studien von basisorientierten Labs in Frankreich, Deutschland und Ungarn, argumentiere ich, dass FabLabs ein signifikantes De-Proletarisierungs-Potential besitzen. Dies resultiert daraus, dass die FabLabs Menschen ermutigen, die technologischen Bedingungen in der Gesellschaft zu problematisieren und die notwendigen Fähigkeiten zu entwickeln, um diese Bedingungen zu verändern. Nichtsdestotrotz haben FabLabs nur einen geringen De-Proletarisierungs-Effekt auf die Gesellschaften, in denen sie aktiv sind, vor allem aufgrund ihrer limitierten und relativ homogenen Mitgliederbasis. Hinzu kommt, dass die FabLabs damit ringen, ihre eigenen Prinzipien von Dezentralisierung und flachen Hierarchien auf die politischen Strukturen der Labs selbst anzuwenden. Damit untergraben sie die Möglichkeiten ihrer Mitglieder, sich neben technologischen Problemen auch politischen zuzuwenden.

Dieser Untersuchung liegt ein auf Fähigkeiten basierender, pluralistischer und nicht-anthropozentrischer, ontologischer Rahmen zugrunde. Inspiriert durch die Arbeit von Gilles Deleuze und dem objektorientierten Ontologen Levi Bryant, argumentiere ich, dass alle Lebewesen, human und nicht-human, durch ihre Fähigkeiten definiert sind zu beeinflussen („to affect"), beeinflusst zu werden („to be affected") und Widerstand zu leisten („to resist"). Dieser ontologische Rahmen ermöglicht es mir, verschiedene Begriffe von Erfindung und Widerstand zu entwickeln, die sowohl Bestandteil meiner Theoretisierung von Proletarisierung sind, als auch Teil meiner Bewertung der FabLabs als Orte von De-Proletarisierung.

Acknowledgements

I would like to thank the University of Kent 50th Anniversary Scholarship Fund for funding this research. I am also indebted to the Graduate School of the Universität Hamburg and Professor Chris Hale at the University of Kent for their generous support throughout this project. And a special thank you to the postgraduate administrative staff at the University of Kent whose work and support I couldn't have done without.

To my supervisors, thank you for all your guidance and encouragement over the years. You gave me the confidence and freedom to take this journey and see it through.

To my fellow doctoral researchers, thanks for all the comradery and commiseration. PhD life can be isolating, especially when you find yourself living in a new city and country at regular intervals, but I had the good fortune of meeting kindred spirits every step of the way whom I now call friends. To Marc and Giulia for our time in Canterbury, to Dennis for Hamburg, and to Jairo for Budapest, thank you for everything we've shared.

My family, to you I owe the intellectual curiosity and perseverance that led me to this point. Merci, je vous adore.

And to Emma, for living this experience with me from start to finish.

Jag älskar dig så jävla mycket.

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Introduction

It is a truism of critical and radical criminology that capitalism is criminogenic. Whether it is by encouraging humans to treat fellow humans, and other nonhuman beings, as means to the end of profit, or by its extremely unequal distribution of material wealth, political power, and harm, capitalism is almost always part of the problem under critical criminological investigation. Embedded in this truism is the notion that a seismic economic shift away from the principle of capital accumulation would have favourable implications for issues of crime and crime control. And yet, contemporary critical criminology exemplifies an unsettling trend among critical scholars more generally, namely, a disregard for material production. Questions about how things are made have been eclipsed by questions about how things are consumed, how they are advertised, and how they are used. In short, questions of consumption outweigh questions of production in critical circles, and have done so for quite some time.

On its face, this trend makes perfect historical sense: as Western economies de-industrialized in the second half of the 20th century, they witnessed the rise of consumer cultures fuelled by marketing, mass media, and the availability of cheap credit. Critical scholars are therefore responding to the issues of their times, as is their purview and, some might say, their responsibility. Be that as it may, I suggest another reason for the decline in critical attention to questions of production. The problem is not that critical thought is distracted by consumerism, but that it is unable to problematize contemporary production processes on account of a deep-seated ignorance of technology, an ignorance that predates the relatively recent transition to consumer capitalism in the Global North. As the technological dimension of material production has grown over time, so too has critical scholarship's inability to formulate problems and solutions that reflect our contemporary technological conditions and productive capacities.

In defence of critical scholars, they are not alone in this predicament. The basic premise of this thesis is that a pervasive technological illiteracy is undermining our abilities as individuals and societies to formulate and respond to pressing social, political, economic and ecological problems. Whether it is global warming, the advent of artificial intelligence, or the future of work, the problems that demand our attention are increasingly bound by technological conditions that the majority of people are unable to understand or affect. Building on the work of the contemporary French philosopher Bernard Stiegler, I employ the term *proletarianization* to mean a process that weakens our abilities to pose and respond to societal problems. I argue that, for nearly three centuries, proletarianization has been driven largely by an accelerated rate of technological change, coupled with an unequal distribution of the human capacities necessary to participate in that change beyond the roles of users and consumers.

Historically, the notion of proletarianization has carried a variety of meanings, but nearly all interpretations have been grounded in the works of Marx and Engels. They define the proletariat as an economic class of wage-labourers who must sell their labour to the owners of the means of production. Proletarianization, therefore, typically denotes the continued expansion of the proletariat as a proportion of society, but it has also been used to signify the degradation of working conditions, as well as a slide in socio-economic standing from the middle to the lower, or working, class.

Stiegler (2010a), however, departs from the Marxist tradition and redefines proletarianization as a loss of know-how (*savoir*) that has affected all echelons of society, not least academia. His work, together with that of his collaborators at the cultural and philosophical association Ars Industrialis, has re-opened the debate on what it means to be a proletarian. For Stiegler, proletarianization is an inherently technological process and, therefore, all the more consequential today in our highly technological societies.

In this thesis, I develop a different understanding of proletarianization that builds on Stiegler's reorientation of the term, but ultimately breaks with his definition. Instead of a loss of know-how, I argue that the proletarian suffers from a weakened ability to problematize his or her circumstances. In so doing, I appeal to the original Roman class designation *proletarii* which inspired Marx's concept of the modern proletariat. On account of their lack of property, the *proletarii* were largely excluded from the political life of Ancient Rome and were therefore unable to participate in the formulation of societal problems. Whereas Marx emphasizes what they did not *have*, my understanding of proletarianization emphasizes what the *proletarii* could not *do*.

Today, the sources of proletarianization are not as apparent as those that held down the *proletarii* of classical antiquity. Rather than facing political discrimination, today's *proletarii* are losing their grasp on a technologically saturated milieu that is in constant flux and constantly generating new problems. It is against this backdrop that I investigate a network of digital fabrication workshops, known as Fabrication Laboratories, or *FabLabs* for short.

Part of the 'maker movement' (Anderson 2012; Dougherty 2012), FabLabs offer people affordable access to digital fabrication machines, such as 3D printers and laser cutters. More than a shared workspace or a tool library, however, a FabLab is meant to foster a local community of makers – people who make their own things – that connects to a global FabLab network. Members of these maker communities are encouraged to share their design ideas and know-how with others, both within their local lab and across the network via online fora, wikis, repositories of digital design files, and video tutorials. Thus, FabLabs aim to create a network effect that enables learning and technological invention. In a FabLab, one learns by doing and sharing.

The purpose of this thesis is to explore the extent to which FabLabs contribute to a process of *de*-proletarianization. If proletarianization weakens our abilities to pose and respond to societal problems, then de-proletarianization strengthens those abilities. Given the technological nature of contemporary proletarianization, FabLabs appear to have an important role to play in reversing this process by giving people an accessible pathway to technological literacy. As people become more technologically literate, they are better able to formulate problems and responses that reflect their contemporary technological conditions. I examine these assumptions, drawing on an ethnographic study of several European FabLabs conducted between the fall of 2015 and the summer of 2017. Based on my findings, I argue that while FabLabs do indeed have a significant de-proletarianizing potential, their current de-proletarianizing effects are weak and poorly distributed across the societies in which they operate. What is more, most FabLabs suffer from a democratic deficit in their organizational structures, which inhibits their members from problematizing the labs themselves as political entities.

I start this introduction by clarifying how it is that I came to formulate this research project that falls decisively outside of the purview of conventional criminology. I explain that it was only after a stunted start to my ethnographic research that I came to the problem of proletarianization as I define it. Next, I briefly introduce my capacities-based ontological framework, and the concepts of invention and resistance that I will use to navigate the dynamics between the FabLabs and proletarianization. Finally, I outline the structure of this thesis.

I. From Digital Piracy to Proletarianization

As a criminologist (of sorts), my original intention was to investigate problems of legality and illegality surrounding the FabLabs and the maker movement, particularly those pertaining to the use and misuse of material protected by intellectual property rights. Given the steady rise in popularity of illicit digital file sharing online, commonly known as digital piracy, and the mounting backlash from industries and governments, I suspected that the maker movement would be the next battlefront in this struggle over intellectual property.

At face value, the maker movement and intellectual property rights appeared to be diametrically opposed to one another. With their culture of free and open knowledge, makers struck me as the kind of people who would ignore a copyright license, or two, in the name of democratizing access to technology. The problem, I soon discovered, was that I had assumed both too much and too little about maker culture. Instead of militant anti-corporatist activists, I encountered politically agnostic tech-enthusiasts, and, instead of pirates, I met people who would rather do it themselves than illicitly download something ready-made. More importantly, I had failed to appreciate a lineage of technological invention that had already paved the way for the maker movement, namely, the free and open source software movement.

i. A Brief History of Free and Open Source Software

During the 1960s and 1970s, it was common practice for computer programmers from different organizations to share their code with one another (Lerner & Schankerman 2010: 35). In the early 1980s, the American telecommunications giant AT&T sought to obtain copyrights on the first major computer operating system, UNIX, developed at the company's Bell Labs. The problem, however, was that

UNIX had benefited from the free circulation of its code on Usenet, a precursor to the modern-day Internet forum that had been set up on the Advanced Research Projects Agency Network (ARPANET), which linked a number of American computer science faculties. The UNIX software was in fact the product of thousands of contributions by programmers, or *hackers* (people who code), that were not employed by AT&T, nor were they likely to receive any final compensation for their work. For a number of hackers, AT&T's attempt and ultimate success in clinching copyrights on the fruits of their collective labour was a call to action.

In 1985, Richard Stallman published his now famous 'GNU Manifesto' (where GNU stands for Gnu's Not Unix) in which he calls upon computer programmers to join in the development of a completely 'free' operating system, GNU, that would be UNIX compatible, meaning that it could run programs designed for UNIX. By 'free,' Stallman does not necessarily mean *free of charge*; it is in fact possible to pay for free software. Instead, freedom means the permission to use, study, modify and redistribute GNU. For a software program to be free, it must include its underlying code so that others can 'study how to program works, and change it to make it do what you wish' (Stallman 2010: 3).

However, the problem was that, by making a program's code public, there was nothing stoping another AT&T from claiming a copyright license on a slightly altered version of that code. In 1984, the MIT released their X Window System (X) as free software and it was quickly adopted by several computer companies who added X to their proprietary Unix systems. The MIT developers welcomed the move as it assured their program would reach a wide audience, but from a free software perspective, X was another example of commercial interests exploiting the collective labour of programmers.

To combat this phenomenon, Stallman published a copyright license in 1989 for GNU software called the GNU General Public License (GPL). The GNU GPL is designed 'to guarantee your freedom to share and change all versions of a program – to make sure it remains free software' (Stallman 2010: 171). Not only does this mean that any software licensed under a GNU GPL must provide its source code, but any modified version must do so as well. The GNU GPL, commonly referred to as the original copy*left* license, uses the privilege that copyright law accords to an author to determine the conditions of use for their products, but ‘flips it over to serve the opposite of its usual purpose: instead of a means for restricting a program, it becomes a means for keeping the program free’ (Stallman 2010: 13).

Nearly a decade later, some prominent members of the hacker community offered a revised version of Stallman’s GPL under the ‘Open Source’ license (Lerner & Schankerman 2010: 44). The new license retained the requirement that a program’s code be made publicly available, but omitted the GPL’s requirement that ‘the open license [be] attached to derivatives of the original code’ (Söderberg 2008: 37). The new guidelines entailed that open source software could be bundled with proprietary code and sold under restrictive copyright licenses. Open source code ‘need not ‘infect’ all code that was compiled with the software with the requirement that it be covered under the license agreement as well’ (Lerner & Schankerman 2010: 45).

The main takeaway from this brief history lesson is that the free and open source software movement proved that it was possible to produce something of great use-value while simultaneously sharing it with others. In fact, it was precisely by sharing code with others, and allowing them to make modifications and improvements, that a program’s use-value would accrue. With the GPL and the open source license, it was also clear that the current intellectual property rights regime would not impede this kind of collective invention.

Thus, the maker movement sought to emulate the success of the free and open source software movement in the production of hardware. Makers tend to license their ideas as either free or open source, and use free and open software if possible. When I would ask my research participants about intellectual property rights and digital piracy, everybody had an opinion, but nobody saw it as a problem that affected the movement or the day-to-day activities of their FabLabs. Given the amount of free and open source license material they had to work with, pirating proprietary content was not only unnecessary, it defeated the purpose of learning and inventing in collaboration with others. In short, file sharing within and between FabLabs is indeed occurring, but not the sort that would interest a criminologist.[1]

1 At least not yet. If 3D printing is able to turn digital data into physical things, 3D scanning technology can turn things into data. A 3D scanner is able to produce a digital 3D model of a physical object by scanning it with a laser light. They are essentially powerful cameras that are more concerned with an object’s spatial properties than its aesthetic qualities. With 3D scanners,

ii. In Search of a Problem

Once I had realized that my original research project was dead on arrival, I found myself in search of a problem. My next move was to approach FabLabs as sites of resistance. The question became: what social, political, legal or economic formations do FabLabs resist, if not the legal regime of intellectual property rights? One such possibility was quite simply that FabLabs challenged the capitalist monopoly on control of the means of production.

The *Journal of Peer Production* dedicated a special issue to shared machine shops and their relation to radical politics. In their editorial introduction, Peter Troxler and maxigas (sic) (2014) ask – half seriously, half in jest – 'we now have the means of production, but where is my revolution?'. FabLabs and other makerspaces, they imply, are the realization of the Marxist goal of a democratized means of production that would free workers of their dependency on the capitalist system for their material reproduction.

The authors are quick to acknowledge, however, that FabLabs are still marginal spaces that 'play a minor role in the production of wealth, knowledge, political consensus and the social organization of life' (Troxler & maxigas 2014). To put it bluntly, FabLabs do not constitute a veritable means of production, nor do they pose an imminent threat to the centralized production practices of contemporary capitalism when it comes to the production of material goods. Moreover, the FabLabs that I had visited were not explicitly endorsing any kind of radical politics, even if their pedagogical strategies were non-hierarchical.

The problem with searching for a direct confrontation between FabLabs, as resistance on one side, and capitalism, as power on the other, is that it is the wrong problem, or rather a poorly formulated problem. It was through this process of trying

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an object can be reverse-engineered from the material artifact to the digital file, thereby circumventing industry's ability to keep their CAD files out of public circulation. While the price of 3D scanners is declining steadily, most models are still a bit too expensive for the average consumer. Besides, their capabilities are still somewhat limited, meaning that corporate interests are not in any imminent peril. That said, the technology is developing rapidly and, while the more sophisticated scanners will continue to be unaffordable for individual consumers, the point of a shared-machine shop is to pool together resources and acquire collectively what is out of reach for the individual. FabLabs could well become hubs for the reverse-engineering of patent protected hardware. The 3D digital models produced by 3D scanners could potentially be illicitly distributed across the same P2P networks that are currently sharing copyrighted media files, but that is simply not the current state of affairs.

to formulate a problem that I started to develop my understanding of proletarianization. Instead of thinking of a FabLab as something that *resists*, I started to think of a FabLab as something *problematic,* in the dual sense of responding to problems and posing problems. In the first sense, FabLabs respond to a variety of different problems for different people. From an individual member's perspective, the problem can be as unambiguous as "I want to use machine *x*, for project *y,* and joining a FabLab is my cheapest option." Others might be driven by problems such as a broken home appliance, a desire for comradery, the need to satisfy certain educational requirements, boredom, or the satisfaction of intellectual curiosity. In the second sense, however, FabLabs are problematic because they problematize technology, and our current relationship to technology.

iii. Problematizing Technology

The vast majority of us encounter technological objects as finished products made somewhere else by someone else. Unlike Ikea or Lego products, technological devices are almost always purchased fully assembled. They appear to us as solid units with fixed forms and specified functions. As prospective buyers, we generally ask ourselves two questions: 'does this product do what I want it to do?' and 'can I afford it?'. We rarely ask: 'how does this product work?' or 'how can I transform it to do something different?'. In other words, we almost always relate to technology as consumers and users, not inventors or makers.

As consumers, we want a device to have certain functionalities, but we also take into consideration, whether consciously or unconsciously, its capacities to affect our social image ("what does this thing tell other people about me as a social being?"). This fact alone is a testament to consumerism's success in creating strong emotive associations between consumers and their products, but it also speaks to an inability to engage with the technological object as a being with a history and latent capacities.

An object's history includes the extraction of raw materials necessary for its production, as well as the exploitative relations between owners and workers emphasized by Marxists. Closer to the object itself, however, there are also the efforts of an inventor, or inventors, to respond to a concrete problem, namely, how to bring together previously disconnected elements into a new durable being with the desired functionalities. An object's history reveals that it is an assemblage of other objects that have found a way to coexist in a relatively durable fashion.

From a consumer's standpoint, there is always only one object counted: the finished product for sale. As an inventor, however, there is always more than one object, and their relations can be altered, that is, they can problematized. The same realization occurs when we have to fix a broken object. The repair involves identifying a faulty or broken connection between an object's parts, or parts of parts. Thus, invention and maintenance both encourage a *pluralist* understanding of technological objects, where the number of objects taken into consideration is always greater than one because the whole never fully absorbs its parts.

Throughout my ethnographic research, I saw invention and maintenance being practiced on both objects that people had made themselves and objects they had bought in a store. I saw that these practices enabled people to problematize the technological conditions of society in ways that I could not, and that this was the true strength of the FabLabs and the maker movement. It appeared that the problem I had been missing was my own diminished ability to problematize.

II. Capacities-Based Ontology & Guiding Concepts

If my ethnographic research of the FabLabs directed me to a revised understanding of proletarianization, it also pointed to an ontological framework that I call a capacities-based ontology. Inspired by the object-oriented ontologist Levi Bryant (2011a; 2011b; 2012; 2014), I maintain that all beings, humans and nonhumans alike, are defined by their singular *capacities* to act and to be acted upon. This ontology is non-anthropocentric because it rejects the notion that there is an ontological difference between human and nonhuman beings.

That said, just because there is no ontological difference between human and nonhuman beings, it does not mean that there are no differences between them whatsoever. Instead, it means that the distinctions are individual rather than categorical. Referring to a being as human or nonhuman suggests that it has certain capacities, but these assumptions must always be verified empirically and should not prejudice the researcher or reader.

The many reasons why I adopt a capacities-based ontology are detailed throughout this thesis. For now, I can state that such a framework is well suited to make sense of phenomena that, like FabLabs, result from a great many interactions between humans and nonhumans. Additionally, it allows me to elaborate new concepts of invention and resistance, concepts that I use to navigate the dynamics between proletarianization and the FabLabs.

i. Invention

In economic theory, an invention typically refers to a novel material change, be it in the process or the product of production. As such, it is intrinsically tied to technological innovation and knowledge creation. To the question 'who invents?', 20th century economists have pointed to three primary sources: individual inventors, private firms that conduct research and development, and non-profit institutions such as universities and government agencies (Allen 1983). It is from within this ecology of invention that FabLabs and the maker movement emerged as a potential fourth source of invention.

My goal, however, is to develop a concept of invention that is non-anthropocentric and therefore more ontological than economic. From the perspective of a capacities-based ontology, I broadly define invention as the activation of new capacities. These capacities can belong to either human or nonhuman beings. In the event that a newly activated capacity belongs to a human, I call this *learning*. When, instead, it belongs to a technological object, I call this *technological invention*. The dynamics between learning and technological invention I call the *politics of invention*.

I argue that proletarianization stems from a disconnected politics of invention. The majority of humans do not learn how to participate in the process of technological invention, while technological invention is not geared toward learning. Nevertheless, technological invention continues to occur at an accelerated rate, the results of which inevitably affect the conditions under which humans live, work, and, indeed, learn. At its core, the issue is a deficiency of compatible capacities residing both in humans and in technological objects.

It is my contention that the FabLabs are developing a politics of invention that is de-proletarianizing because it re-connects technological invention to learning in a virtuous cycle. In so doing, FabLabs ensure that the capacities that are activated in both humans and technological objects are compatible. By increasing the number of possible interactions between humans and technology, FabLabs give their members the opportunity to problematize individual technological objects as well as the technological conditions of society.

ii. Resistance

My capacities-based ontology also changes the concept of resistance from its usual meaning in criminology and sociology. In their article 'To resist = to create? Some thoughts on the concept of resistance in cultural criminology,' Keith Hayward and Marc Schuilenburg (2014: 23) rightly note that 'resistance remains a highly underdeveloped concept within the social sciences.' Once reserved for manifestly political subversive action, such as street protests and clandestine networks of radical activists, the authors lament that the term is now used indiscriminately to refer to any phenomenon that falls outside the mainstream, thereby swelling the concept beyond recognition.

In the hopes of salvaging the concept, Hayward and Schuilenburg (2014: 22) propose a new definition that paints resistance as 'a positive or 'creative force', rather than simply a negative counter-reaction against cultural, social or economical power relations that exist at a particular moment in society.' Resistance, they argue, is a three-stage process of 'invention, imitation and transformation' (Hayward & Schuilenburg 2014: 34). For something to be called resistance, it must transform 'established forms of dogmatic thought' (Hayward & Schuilenburg 2014: 28), the common sense that governs a society, or a particular aspect of it. Without this transformative effect, there is no resistance, only new forms of cultural expression.

In this thesis, I propose an altogether different theory of resistance and its relationship to invention. Instead of conflating resistance and invention, I draw on the works of Foucault (1978), Deleuze (1986; 1988b), and Spinoza (1996) to define resistance as that which limits and restricts the interactions between compatible capacities to affect and to be affected. On the one hand, I argue that it is possible to think of resistance as a third capacity, i.e., the capacity to resist. This capacity gets expressed within a relation between capacities which, following Deleuze (1988b), I call a power relation. While the capacity to resist acts as a variable in the process of invention, invention can also activate new capacities to resist.

On the other hand, there are strategies of resistance that hamper invention by preventing compatible capacities from relating. Such strategies of resistance contribute to proletarianization by constricting our abilities to problematize the technological objects and conditions around us. At this point, the question of intellectual property rights resurfaces, but in a completely new light. I argue that FabLabs can play an important role in exposing many of the strategies of resistance that contribute to proletarianization, further adding to their de-proletarianizing potential.

III. Thesis Structure

In this thesis, I examine the extent to which FabLabs contribute to a process of de-proletarianization. However, I do so from a particular philosophical vantage point that I call a capacities-based ontology. Given that this ontology informs the rest of the work, it is the focus of chapter 1. Building primarily on the works of Deleuze (1994) and Bryant (2011a), I propose an ontology with four registers: the virtual, the intensive, the actual, and the phenomenological. I argue that all beings exist simultaneously in all four of these registers that, together, constitute the real. Once this ontological framework is elaborated, I proceed in chapter 2 to explain how it suggests a particular methodological approach that, following Deleuze and Guattari (1987), I call a cartography. In addition to listing a set of cartographic principles, I also detail the specifics of my ethnographic research.

In chapter 3, I turn to the problem of proletarianization and the various ways in which it has been theorized by Marx, Simondon, and Stiegler. I propose a new understanding of proletarianization as a process that weakens our abilities to pose and respond to problems. Chapter 4 employs the concept of invention to discuss the ways in which FabLabs practice a de-proletarianizing politics of invention. Appealing to the works of Gabriel Tarde and Simondon, I argue that the practices of technological invention encourages a pluralist mindset that allows people to problematize technology. Unfortunately, this de-proletarianizing disposition is poorly distributed in society.

Chapter 5 shifts the focus to the concept of resistance and its role in the dynamics between the FabLabs and proletarianization. In so doing, I propose a new understanding of resistance that builds on the works of Foucault, Deleuze, and Spinoza. I argue that the FabLabs help to reveal certain strategies of resistance that contribute to the problem of proletarianization by inhibiting the invention and the problematization of technology. Ultimately, however, FabLabs must address a democratic deficit in their decision making processes, lest they deny their members the opportunity to problematize the lab as a political entity. Finally, in addition to a summary of my key theoretical and empirical arguments, the conclusion also offers a set of practical proposals for FabLabs looking to increase their de-proletarianizing effect.

1. A Capacities-Based Ontological Framework

Introduction

Social scientific research is based on implicit and explicit ontological decisions. Following the contemporary philosopher Manuel DeLanda (2013: 71), I believe that 'declaring one's ontological commitments from the start should be standard procedure.' While he was referring to philosophers, I see no reason why the same shouldn't hold true for criminologists and sociologists. Ontology is broadly understood as the philosophy of being. It addresses questions such as 'what does it mean to be?' or 'what is the structure of being?'. Social scientists typically avoid engaging with these questions head on, but they are impossible to ignore entirely. Every academic publication aims to describe some phenomenon that is presumably *real*, and therefore makes some kind of ontological claim.[2] In this case, I am proposing an investigation of two phenomena and their interactions, namely, FabLabs and proletarianization. Thus, the first claim that I am making is that these things are real and exist independently of my mind, or this thesis.

As a physical space with a fixed location, made up of material objects and human beings, it is difficult to question the reality of a FabLab. There is a strong predisposition to grant ontological status to those entities that are not only material, but that can affect human consciousness. In other words, we tend to agree that the things that we can touch, smell, see, hear or taste are real, especially if other people have corroborating experiences. FabLabs fit this categorization and are therefore an easy ontological sell. Matters start to get more complicated when we consider things that are not manifestly given to human experience. The FabLab network, for example, is not tangible in the same way as individual labs. People speak of a FabLab network as if it were a *fait accompli,* but making such a determination depends entirely on what ontological criteria networks must meet in general to be considered real.

2Even those publications that aim to critique or reject another's ontological claims do so on the basis of ontological principles.

Discerning the ontological status of proletarianization is harder still. Unlike FabLabs or human beings, proletarianization is not a material thing that one can point to or touch. And unlike the word 'network,' the term 'proletarianization' is unfamiliar to most, and contested for others. A full analysis of proletarianization will have to wait until Chapter 3 but, to reiterate what has already been stated, I argue that proletarianization is a process that weakens our individual and collective abilities to formulate and respond to social, economic or political problems.

In this chapter, I present the ontological framework that informs my investigation of the FabLabs and proletarianization. My task is not to simply list a set of criteria that would allow me to determine whether something is real or not, but to provide an account of how beings interact in such an ontology. In the introduction, I alluded to this framework as a capacities-based ontology that defines all beings by their capacities to affect and to be affected. I also suggested that the practice of invention points to pluralism, where all beings are composed of other beings so that there are always more actors at play than meet the eye. What follows develops these ideas into an ontology that bears some similarities with much of the work produced under the banner of *object-oriented ontology.*

A contemporary school of continental thought, object-oriented ontology, or OOO (triple 'o'), argues that 'the world consists exclusively of objects and treats humans as objects like any other, rather than privileged subjects' (Behar 2016: 1). The use of the term 'object' to denote any individual entity is polemical (Miller 2013) because it aims to elevate that which has hitherto been subordinated in the binary opposition between human subjects and nonhuman objects. Beyond this shared aversion to anthropocentrism, or subjectivism, object-oriented ontologists offer significantly diverging theories about how objects interact and how they are structured (cf. Harman 2005; Bryant 2011a; Bogost 2012; Morton 2013). There are other thinkers who do not subscribe to the OOO label, but whose works share many similarities with an object-oriented approach, such as Bruno Latour (1988; 1999a) and Manuel DeLanda (2002; 2016). In this spirit of heterogeneity, I offer my own variation of an object-oriented ontology, one that builds on many of these thinkers and their intellectual inspirations, particularly Gilles Deleuze (1994).

Deleuze's influence is most evident in my qualified embrace of his tripartite ontological structure, consisting of the virtual, the actual, and the intensive. In *Difference and Repetition,* Deleuze (1994) develops an incredibly rich ontology based on these three registers and their interactions. His ideas have since been taken up by many, resulting in a rich variety of interpretations and elaborations. Rather than adjudicate all these Deleuzian variations, I draw mainly from Deleuze himself, albeit with the assistance of DeLanda (2002) and Levi Bryant (2011), the latter of whom is noteworthy for promoting a capacities-based object-oriented ontology. The main thrust of this chapter is to engage with these authors in order to present my capacities-based ontological structure which adds a fourth register to Deleuze's equation, namely, the phenomenological.

First, I explain in section I why I favour a pluralist ontology over its alternatives, holism and atomism, arguing that the latter are inherently reductionist and ill-equipped to theorize change. In section II, I turn to Deleuze's use of the virtual and the actual as ontological concepts that allow him to theorize becoming without resorting to principles of identity or resemblance. Drawing on Bryant (2011a), I argue in section III that Deleuze's theorization of the virtual should be thought in terms of capacities, for both conceptual and strategic purposes. Finally, section IV addresses the role of the intensive as the mediating register between the virtual and the actual, after which I introduce the phenomenological as the fourth domain of my capacities-based ontology.

I. Pluralism against Holism and Atomism

Before going into the specifics of the four registers of the real that make up my ontological framework, it is important to outline what is at stake in these seemingly impractical deliberations. The first challenge is to overcome anthropocentric theories of agency. These are not only inaccurate, but also strategically costly because they neglect the importance of forming alliances with nonhuman beings to reach socio-political goals. Another concern, however, is that anthropocentrism gives way to theories that disregard individual beings in favour of great totalities that determine all of existence from the top down. In short, I seek an ontology where humans and nonhumans can interact without clumping together to form totalizing structures that strip their components of power.

Holism, i.e. the idea that everything is connected and unified into an all-encompassing whole, is the extreme expression of the kind of thought that pluralists, such as Deleuze, DeLanda, and the object-oriented ontologists, fundamentally oppose. Once again, the reasons to reject holism are not only intellectual, but also practical. If indeed we are determined by the wholes that we compose, then social change is only possible when totalities determine it to occur. Vulgar interpretations of Marxism can exhibit this kind of top-heavy ontology. An economic system's contradictions are exalted as the motor of historical transformation, acting on individuals as would a puppet master. From this perspective, the desire for change truly lies in the system itself, an entity that tends towards the resolution of its contradictions. The systemic desire for non-contradiction trickles down to distinct socio-economic classes, and then finally to individual human beings.

The response to holism, however, should not be the equally reductionist logic of atomism. Whereas holism reduces upwards by claiming that the parts are determined by the whole, atomism reduces downwards by maintaining that there are elementary building blocks of existence that determine everything else. 'Atom' in this context does not refer to the scientific definition of the term, but to that which cannot be divided, much like the term 'individual' implies something that is in-divisible. The problem with atomism is that it rejects the emergence of new capacities. Everything is attributed to a fixed set of capacities residing in elementary units of being.

Instead of holism or atomism, many philosophers have developed pluralist ontologies that give no causal or ontological precedence to wholes or parts. Against holism, pluralists argue that '[t]hings can be related to each other in multiple ways but there is no higher single relation which encompasses them all or which could contain them all' (Lazzarato 2010: 25). Against atomism, pluralism acknowledges that new beings emerge from certain relations between existing entities that complicate the causal mechanisms at play in a given space-time.

To illustrate the differences between these ontological positions, let's briefly contrast the kind of portraits they would produce of the FabLab phenomenon. A holist, say of the vulgar Marxist variety, might argue that the FabLabs are an expression of 'the material productive forces of society com[ing] into contradiction with existing productive relationships, or...with existing property relationships'

(Marx 2004: 168). In essence, technological advancements in digital fabrication have started to clash with property relations, be it the relatively centralized ownership of the means of production, or the ownership of intellectual property. FabLabs may well be the germ of a new economic system, as Marx (2004: 169) argues that 'higher productive relationships never come into being before the material conditions for their existence have been brought to maturity within the womb of the old society itself.' While there is nothing inherently wrong with these claims, restricting one's analysis to these systemic patterns would be grossly reductionist.

What of an atomist portrait of the FabLabs? Atomism is present whenever a type of being is upheld as the determining factor for a wider phenomenon. Biological genes, for example, could be called upon to explain why certain individuals are makers and other not, or FabLabs could be described as the sum product of a series of choices made by rational human actors. Indeed, both atomism and holism are guilty of making rather arbitrary choices as to where to draw the line on causal determinations. Why stop at genes if these are determine by nucleotides composed of atoms, composed of electrons, protons and neutrons, and so on? Likewise, why draw the line at economic systems if these exist in a planetary environment, in a galaxy?

A pluralist, meanwhile, would approach a FabLab with the recognition that there is no single type of being that can causally explain the phenomenon on its own. To a pluralist, a FabLab is a heterogeneous constellation of several beings that are simultaneously wholes and parts depending on the relation under consideration. A 3D printer, for example, is made of a number of components to which it relates as a whole to its parts, but it is also a part of the FabLab as a whole. The key insight is that a whole is never *greater* than its parts, but always *different* to them. Given that this difference between wholes and parts cannot be ontological, a new differentiating factor is required to distinguish individual beings from their parts and the wholes they are a part of themselves.

Following Bryant (2014: 76), I argue that all beings are 'individuated by their powers,' meaning that powers, or *capacities*, are what make a being what it *is*. A FabLab has parts, but it is a unique and distinguishable being because it has its own capacities that differ from those of its parts. For example, a FabLab gathers digital fabrication machines under one roof, machines that can be used together to make objects that no singular machine could produce alone. A FabLab is also the seat of a community of makers that fluctuates over time, with the lab serving as a beacon to attract prospective new members. Moreover, a FabLab is able to form part of a network with other labs, thereby contributing to the emergence of a new being altogether. The list of capacities true to a FabLab goes on, but the point is that these capacities or powers are what make a lab what it is.

In practical terms, this capacities-based pluralism implies that when I walk into a FabLab, the number of interactions that I have with the FabLab itself is actually quite low. I am more likely to engage with all the other beings that are its parts and their specific capacities. Thus, 'the whole exists alongside the parts in the same ontological plane' (DeLanda 2016: 12) as one of many beings in a given space and time. That said, we shouldn't get the impression that wholes and parts are indifferent to each other.

The relationship between a whole and its parts is one of immanent causality. In so far as it has its own unique capacities, the whole is 'irreducible to its parts but [it] do[es] not transcend them, in the sense that if the parts stop interacting the whole itself ceases to exist, or becomes a mere aggregation of elements' (DeLanda 2016: 71). A FabLab is the result of immanent causes, i.e., causes that survive in the effects they produce, and is therefore dependent on the continued interaction of its parts. On the other hand, the lab as a whole exhibits a '*downward causal influence*' (DeLanda 2016: 18, emphasis in original) that affects how its parts behave. Certain capacities are promoted, such as those required to engrave cardboard with a laser cutter, while others are discouraged, such as cutting certain plastics with a laser cutter which would produce fumes that are harmful to humans.

Given these considerations, I can already start to grasp the ontological status of the FabLab network. For the network to be real, it must have capacities that aren't already present in its components – individual FabLabs – and exhibit a downward causal pressure on them. In these respects, the network is real to the extent that it enables the dissemination of information and designs between labs, and puts pressure on individual users to share their work and ideas.

By stating that a being is defined by its capacities, or powers, I go against the idea that beings are to be differentiated primarily by their forms or qualities, such as height, colour, or weight. This move is counterintuitive as a being's capacities are not immediately apparent in our phenomenological experience, whereas we can see its form or qualities if its spatial and temporal dimensions happen to coincide with what our sensorial capacities can handle. Here, we start to sense the fault lines that differentiate the four ontological registers that make up my ontology: the virtual, the intensive, the actual, and the phenomenological. As that which is hidden, or withdrawn, from phenomenological experience, I agree with Bryant (2011a) that a being's capacities are *virtual*, while its qualities are *actual*. Before adding the phenomenological and intensive to the fray, let's first get a sense of what I mean by 'virtual' and 'actual.'

II. Virtual and Actual

The philosophically inclined reader will likely associate the conceptual pair of virtual and actual with Deleuze (1988a; 1990b; 1994; 2004), and rightly so. Originally proposed by Henri Bergson (1988), Deleuze (1994) adopts the concept of the virtual and turns it into a key component of his ontology. Throughout his writing, one of Deleuze's main ambitions is to produce an ontology that does justice to the creative power of existence. Instead of a philosophy of being, Deleuze develops a philosophy of *becoming.* Whereas being elicits connotations of permanence, eternity, and identity, becoming counters with notions of transience, history, and difference. Granted, Deleuze was not the first thinker to emphasize becoming over being, but he sought to rid the philosophy of becoming of its lingering dependence on relations of identity and resemblance.

One such relation lies between the notions of the *possible* and the *real*. The real is said to emerge from the possible, or, better yet, the possible is realized, a process that is 'governed by rules of resemblance and limitation' (Bogue 2007: 276). At every step in a sequence of becoming, a single possible is selected for realization from an array of possibles. Thus, the real is produced 'in the image of the possible that it realizes...[i]t simply has existence or reality added to it' (Deleuze 1988a: 97). And because only one possible is realized per step, the real is said to limit or constrict the possible. Consequently, realization – or becoming – is denigrated to the status of a filter for fully formed futures; 'we give ourselves a real that is ready-made, preformed, pre-existent to itself, and that will pass into existence according to an order of successive limitations. Everything is already *completely given*' (Deleuze 1988a: 98, emphasis in original).

Against this perspective, Deleuze argues for a theory of becoming driven by *difference*. The real does not have to reach outside itself to change because it is already pregnant with a disparity that is transformative. The first difference to note in this process is between the virtual and the actual. Unlike the possible, both the virtual and the actual are *real*. Instead of moving from the possible to the real, Deleuze (1994: 183) argues that becoming occurs 'between the virtual and its actualization.' The actual consists of the multitude of entities that are defined by their 'qualities and parts' or 'qualities and extensities' (Deleuze 1994: 214, 215). As such, the actual is closer to our sensorial experiences of the beings that populate our daily lives, i.e., physical entities with relatively fixed properties that occupy Euclidean space and linear time. Later, I explain why the actual is not equivalent to the phenomenological, but it can be helpful to approximate the two for now.

An actual description of a FabLab, for example, would make an inventory of its physical properties, physical components, geographic location, and important historic dates, like its founding and other significant events. Given our relative familiarity with the actual, the question arises as to why it does not suffice to constitute a viable ontology. Indeed, actualist ontologies do exist and are all too frequent in social scientific research. The problem with these one-dimensional ontologies is that they struggle to explain change, or becoming. If the real is limited to the actual, then a being 'holds nothing in reserve beyond its current relations to all entities in the universe, if it has no currently unexpressed properties, there is no reason to see how anything new can ever emerge' (Harman 2005: 149). In other words, for things to change, there must be a non-actual reserve of reality that gives motion to existence.

For Deleuze, the virtual does more than enable becoming, it structures it as well. Importantly, however, the virtual is not an immutable eternal structure, but is itself a site of becoming and change. Like the actual, the virtual is fully differentiated, but instead of actual entities, it consists of what Deleuze (1994) calls 'Ideas.' Put simply, *Difference and Repetition* is the story of how virtual Ideas become actual entities. Eventually, the intensive individual will be introduced as the third term in this equation, but the main arc relays the Idea to the entity.

In his quest for a theory of becoming devoid of principles of identity and sameness, Deleuze is forced to use a lot of abstract terminology to describe the virtual and its Ideas, much of which is taken from the field of mathematics. For example, an Idea is referred to as a 'multiplicity,' 'a system of connections between differential elements, a system of differential relations between genetic elements' (Deleuze 1994: 181), and a distribution of singular and ordinary points. For my purposes, the key takeaways are that 'Ideas are distinguished from one another' (Deleuze 1994: 187), Ideas are structured composites, and 'the elements of [an Idea] must have neither sensible form nor conceptual signification, nor, therefore, any assignable function' (Deleuze 1994: 183). Most importantly, Ideas are 'made and unmade' (Deleuze 1994: 187), meaning that they are not transcendent or eternal like Plato's ideal forms, but have their own history.

Every actual entity is the incarnation of an Idea (Deleuze 1994: 182), but instead of an actual rendering of a transcendent virtual model, the Idea is *immanent* to the entity. Thus, 'the virtual must be defined as strictly a part of the real object – as though the object had one part of itself in the virtual into which it plunged' (Deleuze 1994: 209). The other, actual, part of the real object is bound to the Idea 'without it being the case that the two halves resemble one another' (Deleuze 1994: 209). The non-resemblance of the virtual and the actual is yet another way in which this conceptual pair differs to that of the possible and the real.

An actual entity's relation to its virtual Idea is that of a solution to its problem. The term *problem*, however, takes on a different meaning in Deleuze's philosophy. According to Deleuze (1990: 54),

> [w]e must break with the long habit of thought which forces us to consider the problematic as a subjective category of our knowledge or as an empirical moment which could indicate only the imperfection of our method and the unhappy necessity for us not to know ahead of time – a necessity which would disappear as we acquire knowledge.

Instead of this subjective understanding of a problem, Deleuzian problems are sets of virtual conditions (singularities and differential relations) that can produce a multitude of solutions, much like a multivariable function in mathematics. An Idea is a virtual problem while an actual entity is its 'local solution' (Deleuze 1994: 211). Unlike the subjective problem that disappears once it is solved, the virtual problem persists under its solution, obscured by the actual entity. Thus, problems, or Ideas, are 'distinct and obscure' (Deleuze 1994: 214): distinct in so far as they are differentiated from one another, and obscure in the sense that they are hidden behind their solutions.

The main practical implication of these abstract considerations is that, rather than start from 'ready-made' problems and concern ourselves 'only with the search for solutions' (Deleuze 1994: 158), the problem itself is what must be unveiled from the solution. Given an actual entity, the challenge is to unearth the problem that it solves, to move from a being's actuality to its immanent virtuality. For Deleuze (1994: 192), this process merits the name of *learning*, 'which is of a different nature to knowledge.' If the latter is the accurate representation of solutions, learning is both the exploration of problems that are incarnated in actual entities, *and the creation of new problems*. Thus, Deleuze does not simply substitute the problem for the solution as the preferred object of knowledge, he wants us to engage with problems so that we transform them and ourselves in the process.

For the social sciences, 'the question is not that of quantifying or measuring human properties, but rather, on the one hand, that of problematizing human events, and, on the other, that of developing as various human events the conditions of a problem' (Deleuze 1990: 55). There are two mechanisms here that cannot be conflated. First, the problematizing of human events, better known as 'deterritorialization' (Deleuze & Guattari 1987) or 'counter-actualization' (Deleuze 1990), moves from the actual to the virtual, extracting the problem from its solution. The second mechanism, however, intervenes in both the actual and the virtual by creating new problems and new solutions, new Ideas and new entities.

Admittedly, it is very difficult to grasp the virtual with the mathematical terminology that Deleuze employs to avoid any resemblance with the actual. The singularities and differential relations that compose Deleuze's virtual Ideas, or problems, require more proximate correlatives if they are to be employed meaningfully in social scientific research. DeLanda (2002: 62) helps us significantly by likening singularities to tendencies and capacities. A Deleuzian thinker through and through, DeLanda (2013: 71) defines a being by its actual properties and its virtual tendencies and capacities:

> Whereas properties are always actual, tendencies and capacities can be real without being actual, if they are not currently manifested or exercised. Thus, the mind-independent identify of a given body of water by determining its actual properties (its volume, purity of composition, temperature, speed of flow) but that determination does not exhaust its reality. Such a body of water may exist presently in the liquid state, but it is part of its reality that at a certain temperature it can become steam or ice, that is, that it has a real tendency to boil or freeze under certain conditions...Similarly, the identity of a body of water is partly determined by its capacity to affect other substances, such as its capacity to dissolve them.

The virtual becomes much more accessible when it is contextualized in this way as the tendencies and capacities that are inherent in a being. In Deleuze's defence, he makes these approximations as well, although he prefers the term 'affect' instead of capacity (Deleuze & Guattari 1987: 257). Regardless, the point is that the movement from a being's actuality to its virtuality entails uncovering its tendencies and capacities. But while these terms are more digestible, they still require greater elucidation.

III. Capacities and Tendencies

Thus far, I have argued that all beings are composite and defined primarily by their capacities. Following Deleuze and DeLanda, I located these capacities somewhere in the virtual half of an object's being. In so doing, I run parallel to Bryant (2011a) whose object-oriented ontology posits that all beings – which he first calls objects, and then machines (Bryant 2014) – are split between their virtual capacities and their actual properties, or 'virtual proper being' and 'local manifestations' respectively. Like Deleuze and DeLanda, Bryant argues that there is a genetic relation between the virtual and the actual: the interactions of virtual capacities are responsible for the production of actual properties, or local manifestations. In this section, I discuss Bryant's thesis and how it helps me to define my capacities-based ontology.

To say that a being is defined by its capacities, or powers, is to say it 'cannot be without its powers or capacities, but it can be without its qualities' (Bryant 2011a: 68). Bryant justifies this claim on the basis that a quality – be it something's colour, weight, height, or form – is always the product of multiple capacities acting in concert in a given location. The colour of the North Sea, for example, is not a fixed property, but a temporally fluctuating expression of its capacity to reflect varying degrees of sunlight. At night, when there is no light, the sea is quite literally black. Despite these fluctuations in colour, the North Sea remains what it is because its capacities haven't changed, even if their manifestations have.

It is important to note that Bryant's argument is not a phenomenological one; it doesn't matter whether or not there is a human subject to witness the fluctuations in object's actual properties. Human or no human, many actual properties undergo constant changes due to the transient interactions of various capacities. Because these fluctuating properties, or qualities, are the outcome of collaborations between multiple beings, 'we must not say that an object *has* its qualities or that qualities *inhere* in an object, nor above all that objects *are* their qualities, but rather in a locution that cannot but appear grotesque and bizarre, we must say that qualities are something an object *does*' (Bryant 2011a: 69). Crucially, this *doing* is always a *doing with others*.

Just as Deleuze maintains that the problem is obscured by its solution, Bryant (2011a: 88) asserts that 'no one nor any thing ever encounters an object *qua* its virtual proper being...[r]ather, the virtual proper being of an object can only ever be *inferred* from its local manifestations' (emphasis in original). A being's virtual capacities are, to use a Heideggerian term, *withdrawn*, not only from phenomenological experience, but from the actual qualities themselves. Consequently, the ontological task remains the same: to pass from the actual to the virtual, from variant qualities to invariant capacities.

What, then, is a capacity? In the most general of terms, capacities are relational factors that enable the production of differences. They are relational in a number of ways. First, capacities relate to each other as the virtual elements of a being's virtuality, whether this be referred to as an 'Idea,' a 'problem,' a 'multiplicity' (Deleuze 1994; DeLanda 2002), or 'virtual proper being' (Bryant 2011a). If 'the virtual is completely determined' (Deleuze 1994: 209), it is according to these relations between capacities that form distinct virtual units, distinct virtualities.

The second way in which capacities are relational is in their actualization. Here, we must distinguish between capacities to affect and capacities to be affected. The notion that 'the power to be affected is no less a power than the power to affect'

(Deleuze 1986) is most readily attributed back to Spinoza (1996). Quite simply, a being's capacities to be affected are what make it receptive to its outside: the eye's capacity to be affected by certain electromagnetic wavelengths, the computer's capacity to be affected by electric currents, or the 3D printer's capacity to be affected by digital information.

Meanwhile, the capacity to affect is perhaps the most commonly associated with power. A being *affects* when it provokes a difference in another being. The upshot is that a 'capacity to affect must always be coupled to a capacity to be affected' (DeLanda 2013: 72) for a difference to be actualized. A laser cutter has the capacity to affect wood, whether by cutting or engraving it, because wood has the capacity to be affected by the laser. Therefore, the cut itself is the product of both entities, not just the laser cutter. In a later chapter, I will argue that there is reason to include a third type of capacity, namely, a capacity to resist which, like capacities to affect and to be affected, is present in all beings, human and nonhuman.

Capacities are a good substitute for singularities when thinking about the virtual because they hit closer to our lived experience. Bryant's capacities-based ontology is commendable for making Deleuze's ontological framework more accessible, but he does so at a cost. For one, he accuses Deleuze of dabbling in monism, an accusation that largely rests on a misinterpretation of the term 'pre-individual' which Deleuze (1994), following Simondon (2007), uses to describe his virtual Ideas. Whereas Bryant (2011a: 96) claims that the use of the term 'implies a transition from an *undifferentiated* state to a differenciated [(*sic*)] individual' (emphasis in original), Deleuze (1994) speaks of pre-individual virtualities to distinguish them from intensive individuals, a notion that I address in the following section.[3] Indeed, one of the limitations of Bryant's thesis is that he does not address the intensive as a separate register of his ontology.

These shortcomings notwithstanding, Bryant's advantage over Deleuze is his applicability to social scientific research. If Deleuze's philosophical ambition is to

3 And as someone who wrote a whole book on Deleuze (cf. Bryant 2008), Bryant would appreciate the irony of using Deleuzian terminology, albeit misleadingly, in his attempt to distance himself from the Frenchman, as Deleuze (1994) uses the term 'differen*t*iation' to refer to the differences of virtual Ideas, and 'differen*c*iation' when speaking of actual entities. Bryant inadvertently affirms this terminological distinction, while introducing the notion of the 'undifferentiated' which is foreign to Deleuze's thought. Deleuze (1994: 258) is quite clear on the point that 'the pre-individual is still singular.'

‘make the virtual *intelligible*’ (DeLanda 2002: 174, emphasis in original), then the critical social scientist must do the same without losing sight of the strategic and political reasons for doing so. By framing the virtual in terms of capacities, we can better engage with sociological and criminological phenomena, not to mention other social scientists, as well as develop a political project around the normative principle of capacity building.

Before moving on to a discussion of the intensive and the phenomenological registers of my ontology, I should clarify why I believe that capacities are preferable to tendencies as a being’s determining attributes. In his example of a body of water, DeLanda (2013: 71) explains that ‘at a certain temperature it can become steam or ice, that is, that it has a real tendency to boil or freeze under certain conditions.’ Of course, his description is perfectly correct. But when things are defined by their powers, it becomes apparent that, ontologically speaking, water, steam, and ice are distinct beings with their own set of capacities to affect and to be affected. This is not to deny the intimate links between the three, but it shows the extent to which beings are bound by environmental requirements that impose clear limits on their existence. Rather than say that water has a tendency to become ice or steam, we should think of these critical intensive thresholds – boiling and freezing points – as the limits of the water’s capacities and its ability to exert a downward causal influence on its parts, and the moment of a new being’s emergence.

IV. The Intensive and the Phenomenological

If virtual capacities can be actualized in a myriad of different qualities and extensities, it is incumbent upon us to understand why a particular actualization occurs, and not another. Clisby (2015: 128) notes that there are two conflicting interpretations of Deleuze’s theory of the virtual and the actual, what he calls ‘the views of ‘virtual priority’ and ‘reciprocity’.’ The ‘virtual priority’ position states that all the creative power of the real lies in the virtual which totally determines the actual, whereas the reciprocal view argues that the virtual and the actual are equally important in the constitution of the real. The danger in positing the primacy of the virtual over the actual is that we might turn virtualities – Ideas, multiplicities, or virtual proper beings – into shadowy subjects that choose at will when and how to actualize. That said, the reciprocal view is also problematic because it neglects a third register of Deleuze's ontology, namely, the *intensive* which mediates between the virtual and the actual.[4] After elaborating the role of the intensive, I complete my ontological framework by detailing the *phenomenological* register that I draw from object-oriented ontologists and others.

Intensity is, first and foremost, a thermodynamic concept. Temperature, pressure, tension, and potential are all intensive properties of energy that thermodynamics monitor in open and closed energetic systems. What draws Deleuze to these properties is that differences in intensity are productive. The most elementary example of this productive difference would be a primitive motor composed of two chambers, one containing hot air, the other cold air. Given the difference in temperature between the two, opening a channel between both chambers would trigger the flow of some of the warmer air to pass into the cooler container, thereby creating an energy current that could be used for mechanical work. If the system is closed, meaning that no new energy is introduced from an external source, eventually the difference in temperature will be erased, along with the motor's capacity for work. Introducing an external energy source, however, would open the system and allow the motor's energy current to continue until that additional energy is distributed and the system reaches a state of equilibrium.

Deleuze (1994: 222) argues that intensive differences, or intensities, are 'the sufficient reason[s] of all phenomena, the condition[s] of that which appears.' In other words, for every actuality – quality or extensive property – there is an intensive difference that caused it to occur and not another. As is implied in the notion of an intensive *difference*, intensities are 'made of relations between asymmetrical elements' (Deleuze 1994: 244), i.e., unequal intensive quantities which are themselves intensities made of relations between other intensities. Deleuze posits that intensities correspond to Ideas, and that the interactions between intensities determine an Idea 'to actualize itself, to incarnate itself in a particular way' (Deleuze 2004: 102).

4 Many have tried to lump the intensive into either side of the virtual/actual divide. Clisby (2015) himself, for example, argues that the intensive should be considered a part of the actual but I see no evidence of this theory in *Difference and Repetition*. If anything, Deleuze prioritizes the intensive over both the virtual and the actual as the sufficient reasons of a virtual Idea's actualization and the motor of becoming in his ontology.

At this point, it is important to distinguish several operations that belong to the intensive. First, when intensities relate, the difference between them forms a new intensity which Deleuze (1994: 246) calls an 'individual.' The new intensive individual activates a virtual Idea. This *activation* of the virtual in an individual is the first intensive operation. It immediately triggers a process of *individuation*, the second intensive operation, which consists of the individual interacting with other intensities in its environment, or 'field of individuation' (Deleuze 1994: 247). The individual can relate to other intensities, forming new individuals in the process, but it also undergoes its own unique transformations. When an individual is created, it does not activate all of its corresponding virtual Idea at once. Instead, Deleuze (1994: 246) maintains that an individual 'finds itself attached to a pre-individual half,' i.e., an Idea, throughout the process of individuation, the latter being a 'reservoir of its singularities' that the individual activates sequentially. Thus, activation is not a one-off event, but a recurring operation over the course of an individual's individuation.

The third, and final, intensive operation is the *explication* of the individual into an actual entity with qualities and extensive properties. Whereas in thermodynamics intensive differences produce extensive properties by cancelling themselves out, Deleuze argues that the actual covers rather than cancels the intensive. As a consequence, the intensive individual is not destroyed when it is explicated into an actual entity, but concealed by it, resulting in 'the disguising of process under product' (DeLanda 2002: 59). Instead of constituting a synthesis of intensive differences, the actual entity is another layer of difference that resembles neither the individual that explicated it, nor the Idea it actualizes.

Given that the individual persists under its explications, I disagree with DeLanda (2002: 195) when he claims that 'a fully developed human being would be an actual entity, but the embryo as it is being unfolded and developed would be an individual' (DeLanda 2002: 195), the implication being that an adult human being has somehow lost its status as an individual because it is no longer in a process of individuation. Were that the case, the adult human would be a completely static, empty shell of a person, incapable of change, cut off from an intensive environment, claims that DeLanda would not support. I believe this misconception stems in part from Deleuze's tendency to refer to eggs and embryos in his discussions of the intensive and the process of individuation. Far from being a metaphor, the embryo is an excellent example of a being whose intensive individual is undergoing an extreme process of individuation, corresponding frequently with its virtual Idea, and producing dramatic changes in its actual qualities and extensities. Nonetheless, the anatomically developed human being has its own individuality and process of individuation without which it would be dead.

We are finally in a position to appraise Deleuze's ontological framework, at least as it is presented in *Difference and Repetition.* His tripartite ontology of the virtual, the intensive, and the actual offers an incredibly rich account of becoming, without resorting to totalizing structures, or principles of resemblance and identity. For every being, there is a virtual Idea, an intensive individual, and an actual entity, none of which resemble each other, all of which are equally real. Between the virtual and the actual, the intensive acts as the dynamic medium, responsible for activating the virtual, individuating, and explicating itself into the actual. The end result is a layered ontology where the actual conceals the intensive and the virtual, forcing the philosopher and social scientist alike to find ways to pass from the actual to the other registers.

Instead of Deleuze's Ideas and 'singularities,' I posit a virtual realm that is populated by virtualities and capacities. Every virtuality is a set of capacities, a claim that is quite similar to Bryant's theory that a being's 'virtual proper being' consists of its powers. Unlike Bryant, however, I retain Deleuze's theory of the intensive as a separate register of the real that mediates the virtual and the actual. Virtual capacities do not *choose* or *will* their manifestation in the actual as would a sovereign subject; they are activated by intensive individuals undergoing individuations, the results of which are explicated into the actual. The interactions between a being's intensive individual and other individuals determine how its capacities are actualized.

That said, the interactions that an intensive individual can have with others are determined by the virtual capacities it activates. Two intensive individuals can only relate if they have corresponding capacities to affect and to be affected that are activated. Individuals that do not have corresponding capacities cannot relate to form new individuals, nor participate in each other's individuation. In this regard, the virtual structures the intensive, while the intensive produces the actual.

What happens to the actual? Up until now, the little we know is that the actual conceals the intensive processes and the virtual capacities that produce it. We can also gather that it changes with every new explication, creating a sequence of events that is close to human lived experience, but not identical to it. Indeed, I argue that a fourth ontological register is necessary to account for the lived experience of all beings, human and nonhuman, a register that I call the *phenomenological.* While Deleuze does not explicitly develop a phenomenological dimension to his ontology, I claim that such a dimension can and should be added to his tripartite structure.

When I pick up a 3D printed figurine, I can appraise its actual qualities and extensities, its shape, colour, and size. However, I do so via my capacities to be affected by external stimuli, capacities that are *selective*. The figurine as it appears to me is different to the actual figurine, because my capacities to be affected can only register a fraction of its actuality. What is more, my capacities do not only select from the actual, but also transform those selections into a phenomenological object. Whereas the actual figurine is real regardless of whether I look at it or not, the phenomenological figurine owes its reality to my capacities to select and transform external stimuli into a distinct phenomenon. The latter exists exclusively for me, while the former is totally mind-independent and available to all beings with the capacities to be affected by it.

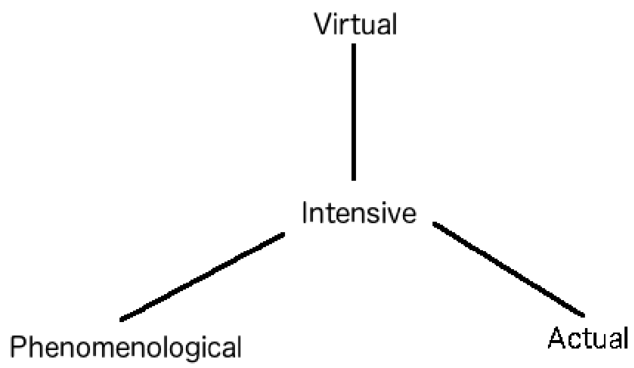
That the actual is not the phenomenological is a key principle of object-oriented ontology. For Bryant (2011a: 88), local manifestations, his term for actual qualities and properties, do not presuppose a human subject in the slightest; '[t]he universe could be a universe in which no sentient beings of any sort exist and manifestation would continue to take place.' But how to characterize the phenomenological domain? In the example of the figurine, we have already gleamed a few insights into this fourth register.

A being's capacities to be affected open a phenomenological realm that is unique to that being alone. These capacities act on the actual, selecting and transforming actual states of affairs into phenomenological content. Following Latour (1986), I call these transformative selections *translations*. As a consequence, a being's phenomenological realm is its unique translation of the actual. Stated differently, every being 'makes a whole world for itself' (Latour 1988: 166) according to the translations it is able to carry out on the actual.

The problem with my example is that it runs the risk of implying that the phenomenological is reserved for human beings. This is not the case. While it is impossible for us to access a nonhuman being's phenomenological realm, we should not assume that such realms do not exist. Given that every being has capacities to be affected, it is probable that these too open singular phenomenological realms, however different these may be to our own. I therefore agree with Ian Bogost (2012) and his notion of an *alien phenomenology* that grants a phenomenological realm to all beings, realms that would strike us humans as strange or, indeed, alien.

Adding the phenomenological to Deleuze's tripartite ontology means that, for every being, there is a virtuality (a set of capacities), an intensive individual, an actual entity, *and* a phenomenological realm. The phenomenological is the product of virtual capacities that, having been activated in the intensive, are able to selectively draw on the actual and translate it into another register. Thus, all three of Deleuze's ontological domains are enmeshed in the production of the phenomenological albeit to varying degrees of involvement.

If, initially, the phenomenological appears closest to the actual, it is by virtue of its activated capacities that a being selects from the actual and transforms it into phenomenological content. It is more accurate, therefore, to state that the phenomenological is closest to the intensive, or rather, that the intensive mediates the relations between the phenomenological and the actual, as well as those between the virtual and the actual. The intensive also acts as a mediator between the phenomenological and the virtual, making it the central pivot of my ontological framework. Presented diagrammatically, this ontology would assume the following configuration:



Conclusion

In this chapter, I introduced the ontological framework that guides my research project. Building off of Deleuze's tripartite ontology, I developed a capacities-based ontology that adds the phenomenological to the virtual, the intensive, and the actual, as the fourth register of the real. My ontology is 'capacities-based' because I argue that a being is defined primarily by its capacities to affect and to be affected, capacities that are bundled together in a virtuality. Those capacities are sequentially activated by the being's intensive individual as it undergoes a process of individuation. In this process, individuals interact according to the capacities they have already activated, and only individuals with corresponding capacities to affect and to be affected can participate in each other's individuations. More is to be said on these intensive interactions in subsequent chapters, but the key takeaway is that the virtual structures the intensive which, in turn, explicates itself into the actual as entities with qualities and extensities. The intensive also mediates relations between the virtual, the actual, and a fourth register, namely, the phenomenological. Every being has an exclusive phenomenological realm that it alone can access.

Thus, a being is a virtual set of capacities, an intensive individual born of intensive differences, an actuality that consists of qualities and extensities, and a phenomenological realm filled with phenomena. To say that a being is defined primarily by its capacities, is *not* to say that its other elements are unimportant or not real. Instead, it means to highlight those parts of a being that structure its becoming. Intensive individuals and fields of individuation are just as important because they determine how and when virtual capacities are actualized, as well as mediate the relations between the other three registers.

Prior to elaborating this fourfold ontological structure, I insisted on the composite nature of nearly all beings, and argued that the relationship between whole and parts is never totalizing, and always immanent. Taken together, all of these considerations result in an intricate ontology where more is at play than meets the eye, both in terms of more beings, and more dimensions. Practically, the challenge is to find methodological strategies to navigate this layered ontological landscape without losing sight of the problem of proletarianization and the FabLabs, a challenge that I address in the following chapter.

2. A Cartographic Method

Introduction

The aim of this chapter is to provide an account of the methods used to investigate the extent to which FabLabs contribute to a process of de-proletarianization. Generally speaking, these methods were qualitative and ethnographic. My fieldwork consisted of 20 semi-structured interviews, and months of participant observation conducted in a total of six FabLabs located in Paris, Hamburg, and Budapest. I focused the majority of my research efforts on le Petit Fablab de Paris, Fabulous St Pauli in Hamburg, and FabLab Budapest. These labs were selected for a variety of reasons, not least due to biographical considerations, seeing as I spent a combined year and a half of my doctorate living in Hamburg and Budapest. Both of these cities each only had a single operational FabLab at the time, Fabulous St Pauli and FabLab Budapest.

Paris, meanwhile, has at least eight active FabLabs, half of which I visited over the course of three separate fieldwork excursions, totalling more than a month. That Paris has a more developed FabLab ecology than Hamburg and Budapest proved beneficial in understanding the dynamics between labs in close geographic proximity to one another. Le Petit FabLab de Paris became my preferred research site in part thanks to a strong personal rapport, but in larger part due to their politics and organizational structure. The lab had also recently transferred to a new location, allowing me to catch glimpses of a lab in its early phases of setting up anew.

In addition to in-person ethnographic research, no analysis of the FabLab phenomenon would be complete without an investigation of its massive online presence. As physical spaces connected by the sharing of digital information across the web, FabLabs challenge the sociological distinction between traditional and 'virtual' communities. In this case, the term 'virtual' alludes to its more common usage, in the sense of 'virtual reality,' or that which is mediated by digital technology. Concretely, my 'net'nographic research involved searching through websites affiliated with the FabLabs I visited in person, and other sites designed to facilitate the sharing of information between labs. The assumption was that these online platforms were the clearest manifestation of the FabLab network as such.

Throughout my research, I applied a set of critical methods that flow from the ontological framework detailed in the previous chapter. Following Deleuze and Guattari (1987), I call these methods *cartographic*. While cartography is most commonly defined as the drawing of maps, the methods I outline below bear little resemblance to this geographical practice. What is retained, however, is the sense of unchartered territory, the delineation of previously obscure relations, and, above all, the notion that the finished product is meant to be useful. A good map is not necessarily the most accurate map, but one that selects the most relevant information and communicates it effectively. In this case, accuracy is secondary to the map's ability to help us navigate the problem of proletarianization and its relation to the FabLabs.

Even in cartographic practices of geographers, accuracy and utility are synergetic, but only to a degree. Depending on their goals, map makers have to choose between conformal maps that preserve a territory's shape, and equal-area maps that respect the relations between areas and lengths:

> For the purposes of navigation along a coastline, where visual recognition of landmark shapes is what matters, a conformal map is the right choice, but for statistical purposes, to depict the density of population per square mile, for example, we need an equal-area map.
>
> (DeLanda 2010: 118)

The cartographer will have to forgo some accuracy in that which is less relevant to the task at hand. Truth does not disappear so long as truth is not conflated with exactitude. Whereas exactitude refers to a stable actuality, the cartographic method I propose treats the actual alongside the virtual, the intensive, and the phenomenological, as four registers of the real that interact without resembling each other. The challenge isn't to map crystallized relations between beings, but to follow the patterns of becoming that exist within and between these registers. Thus, I should stress that the purpose of this method is not necessarily to produce a visual map of relations between human and nonhuman beings. Maps, in the familiar sense, can be extremely important tools for critical scholarship (cf. Matallana-Villareal 2017), but to reduce my understanding of cartography to a visual method is to conflate it with the mapping of the actual.

In this chapter, I detail this cartographic method as it relates to my ontological framework and my research question. But, first, I start by problematizing the use of the term ethnography to denote a specific method, let alone a critical one. Despite their similarities in practice, ethnographies differ substantially in their epistemological and ontological presuppositions. Thus, section I discusses these differences as they are laid out by Deleuze and Guattari (1987) in the 'Rhizome' chapter of *A Thousand Plateaus,* in which the authors propose a cartographic approach to social inquiry that I embrace with some adjustments. In section II, I detail the cartographic principles that I applied in this research project. Finally, section III goes into the empirical specifics of the research I conducted on FabLabs in person and online.

I. From Book-Forms to Research-Forms

Deleuze and Guattari's *A Thousand Plateaus* starts with a curious typology of book forms. More precisely, it starts with a working definition of a book as a 'little machine' (Deleuze & Guattari 1987: 4). What is a machine? In their first collaboration, *Anti-Oedipus,* Deleuze and Guattari (1983: 1) describe a reality that consists of 'machines driving other machines, machines being driven by other machines, with all the necessary couplings and connections.' Thus, machines are what I call beings or what OOO calls objects, i.e., the basic units of the real. All machines transform inputs into outputs through a series of operations. From a capacities-based perspective, I might say that a machine has the capacity to be affected by specific inputs and the capacity to transform them into outputs.

For a book to be a machine, it must both produce a flow of outputs, as well as cut into other flows. Taken as an output-producing machine, the book offers a flow of writing that our organ-machines – be it the eye, the ear, or the finger – can cut into as inputs. If, however, we approach the book as an input-receiving machine, it is less apparent what flows it interrupts, that is, what inputs it operates on. This is where Deleuze and Guattari's typology of book forms comes into the picture.

The first type of book discussed is the root-book. This 'classical book' functions according to 'the law of reflection, the One that becomes two' (Deleuze & Guattari 1987: 5). The unity of the world (the One) is reflected and therefore doubled in the unity of the book. Philosophically speaking, the root-book, or tree-book, resonates with positivist theories of knowledge where truth is singular and representable.

The second type of book is based on the radicle-system. Dualism dwells in this model as 'unity is consistently thwarted and obstructed in the object, while a new type of unity triumphs in the subject' (Deleuze & Guattari 1987: 6). 'The world has become chaos,' announces the author, 'but [his] book remains the image of the world: radicle-chaosmos rather than root-cosmos' (Deleuze & Guattari 1987: 6). So while they have differing interpretations of reality, the root-book and the radicle-book both act as mirrors of an outside that is unscathed by the book's gentle glare.

Against these hegemonic forms, Deleuze and Guattari propose a third kind of book. The rhizome-book does not search for an immutable unity or chaos to (re)present. Instead, it intervenes as a machine that cuts into the real and transforms it into something different, a machine that connects to other machines and thereby helps shape a world that is in constant flux, never saturated in its possibilities for transformation; 'an unfinished and unfinishable universe' (Lazzarato 2010: 27).

If the root-book and the radicle-book function according to the logic of tracing and reproduction, the rhizome abides by the cartographic logic of the map. Deleuze and Guattari are not postmodern extremists advocating for an 'anything-goes' approach to knowledge production. The image of the rhizome is not a celebration of incoherence or obscurity. Instead, a rhizomatic book 'forms a rhizome with the world' (Deleuze & Guattari 1987: 11), mediating connections between other machines and affecting them in the process. And while a map has an aesthetic quality, it is 'entirely oriented toward an experimentation in contact with the real' (Deleuze & Guattari 1987: 12). A given map must be questioned, not on its accuracy, but on the forms of experimentation that it encourages or discourages.

Root-book, radicle-book, and rhizome-book, I believe that these three book forms are metonymies for three different ways of conducting and understanding knowledge production and research. The root-book alludes to a pre-critical epistemology, absolutist ontology, and naive positivism. Not only is the world whole, rational, and eternal, we humans are able to make sense of this reality directly. Knowledge is a cumulative process, a steady clearing of the shadow of error and ignorance leading to full enlightenment. Politically speaking, this perspective prescribes a search for *the* truth, *the* good, *the* law, and their practical implementations.

Conversely, 'radicle-research' uses a critical epistemology to investigate a world that is splintered, but not irreparably so. Endowed with reason and suspicion, the researcher can uncover deep structures and causal mechanisms that reinstate an ideal unity in human thought, or reveal the becoming of being to be teleological. The political project becomes a question of identifying structural movements and trying to find contradictions in the system to exploit towards a particular end. 'Radicle-research' resides where one hears '*in the last instance...*'. Most forms of structuralism, Hegelian Marxism, psychoanalysis, and phenomenology exemplify this approach, prevailing in the 'critical' wing of a given discipline.

What then of rhizomatic research? Ontologically, we are in a pluralist universe where every relation between machines – or beings – makes a difference, and therefore produces reality. Rhizomatic research embraces the idea that '[t]here is only one kind of production, the production of the real' (Deleuze & Guattari 1983: 32). To produce a doctoral thesis (or any other kind of research for that matter) is to produce a machine that takes inputs (data) and transforms it into outputs (a book, journal articles, conference papers). The key difference with rhizomatic research is the acceptance that differences and translations are not only pervasive across the research process, but an essential part of the real itself.

When a machine cuts into a flow, it doe not extract an unadulterated product – objective data in the case of research. A cut is a difference made. Thus, a machine produces its own input in collaboration with others. Strictly speaking, inputs do not precede the machine that acts on them. Difference is produced at every step of the research process, not only in the production of input and output, but also in the production of the research project and the researcher him or herself.

Ethnographies can assume any of these forms – root, radicle, or rhizome – depending on the researcher's ontological and epistemological commitments. While ethnographers are predisposed to acknowledge that the intimacy they establish with their subject matter comes at the cost of some distortion of the 'truth,' not only is this not always the case (there are plenty of root-ethnographers), but there is also a prevailing sense that with enough 'reflexivity' – awareness of one's effects on research participants and one's inherent biases – that the noise can be cancelled and the truth made clear again (radicle-ethnography). Only rarely does the difference producing aspect of ethnography get taken to the ontological conclusion that differentiation is both an inevitable and positive part of research. That said, method is important in so far as it explains how, and on the basis of what assumptions, these differences are made. Hence, the following sections explains how my capacities-based ontology informs my cartographic method and the principles that I followed in my research.

II. Cartographic Principles

In the previous chapter, I outlined an ontology of composite beings that simultaneously inhabit four registers of the real. Not only does this ontological framework apply to the subject matter of my investigation, it also applies to the research process itself and to my own situation as a researcher. In other words, it is not enough to posit and apply an ontological framework to a particular research question as if it were some topical ointment; one must be immersed in it, swim in it like a fish in water. Concretely, this means that I myself am a being that exists in the virtual, the intensive, the actual and the phenomenological. I am at once a set of virtual capacities, an intensive individual enmeshed in an intensive environment, an actual entity with physical qualities, and I have my own exclusive phenomenological realm. If that weren't enough, I am also composed of trillions of other beings who also exist across four registers. As messy as that sounds, remember that the objective is not exactitude so much as determining what is relevant to the problem at hand.

The first cartographic principle is to recognize that the researcher is part of the territory to be mapped. Not only is the whole enterprise constrained in a sense by my capacities to be affected, I also inevitably translate those elements of the actual that affect me into a phenomenological realm that I alone have access to. Once these external stimuli have been translated into internal phenomena, they continue to be acted on by earlier phenomena that have become memory. These operations specific to the phenomenological produce differences as well, differences that can be communicated back to other registers, but not without undergoing more transformations. Every ontological register is 'constituted by differences, and communicates with the others through differences of differences' (Deleuze 1994: 278).

Methodologically, the challenge is to navigate these transitions from register to register, that is, to find ways to tap into the processes of becoming that occur between the phenomenological, actual, intensive, and virtual registers of the real. On a more practical note, including myself in the territory to be mapped means that I can, and will, draw on personal experiences related to the problem of proletarianization, for I consider myself very much a member of the proletariat as I understand it.

How can one navigate a multilayered ontology, where none of the layers resemble each other? In *A Thousand Plateaus,* Deleuze and Guattari (1987) propose a cartographic method designed to explore their similarly intricate ontology. As in geographic cartography, they employ the variables of longitude and latitude to organize their maps although, unsurprisingly, these terms take on a completely different meaning. In their case, latitude refers to the intensive register of the real, while longitude designates the actual. While it is notable that there is no third coordinate for the virtual, I will shortly offer an explanation for why that is the case, but first, let us look at how Deleuze and Guattari understand the terms longitude and latitude.

Deleuze and Guattari always discuss longitude and latitude in relation to individual beings. Every being has a latitude and a longitude. On the one hand, a being's latitude is 'constituted by a certain number of composable individuations' (Deleuze & Guattari 1987: 253). Individuation is one of the operations proper to the intensive register, undergone by an intensive individual. To say that individuations are composable means that individuals can '[enter] into composition...to form another individual' (Deleuze & Guattari 1987: 253). Not only are intensive individuals composed of other intensive individuals, they also regularly enter into new compositions to form new individuals, all of this without losing their own unique individualities. Therefore, a being's latitude is '*made up of intensive parts*' (Deleuze & Guattari 1987: 257, emphasis in original), related individuals of different intensive quantities.

Longitude, on the other hand, corresponds to a being's '*extensive parts*' (Deleuze & Guattari: 257, emphasis in original). These extensive parts are actual, meaning that they are explications of the intensive differences that constitute a being's latitude. Given that the intensive generates the actual, we can add that a being's latitude produces its longitude. Consequently, to do 'a cartography' is 'to establish latitudes that are...speeds, slownesses, and [intensive] degrees of all kinds corresponding to a body or set of bodies taken as longitude' (Deleuze & Guattari 1987: 254). The goal is to understand the intensive movements that give rise to actual entities and their extensive parts.

What then are the concrete implications of this cartographic approach? How does a researcher establish latitudes? Fortunately, Deleuze and Guattari (1987: 256) offer a second definition of latitude, namely, 'the affects of which [a body] is capable.' They add,

> We know nothing about a body until we know what it can do, in other words, what its affects are, how they can or cannot enter into composition with other affects, with the affects of another body, either to destroy that body or to be destroyed by it, either to exchange actions and passions with it or to join with it in composing a more powerful body.
>
> (Deleuze & Guattari 1987: 257)

Here we have one of the clearest instances of a capacities-based logic in Deleuze and Guattari's work. That said, we must tread carefully, especially with the terminology they employ. Most of these passages are taken from sections in *A Thousand Plateaus* that discuss the philosophy of Baruch de Spinoza, a key influence on Deleuze's own thought. It comes as no surprise, therefore, that the terminology they use is distinctly Spinozist, 'affects' being the most significant of these terms.

In the previous chapter, I likened Deleuze's use of the word affect to my use of the word capacity, but an important clarification can now be made. Simply put, affects are intensive, whereas capacities are virtual. A being's intensive individual undergoes affects whenever it interacts with other individuals, other intensities. Spinoza (1996: 70) defines an affect as that 'by which [a] body's power of acting is increased or diminished, aided or restrained.' Affects are transitions between different intensive states, not the virtual capacities themselves.

This distinction is not lost on Deleuze. 'Affects are becomings' that a being is capable of 'at a given *degree of power*, or rather within the limits of that degree' (Deleuze & Guattari 1987: 256, emphasis added). The degree of power is the virtual part of a being, the Deleuzian Idea, what I refer to as a virtuality, or set of virtual capacities. Affects, meanwhile, are the intensive becomings that an intensive individual is capable of, given the virtual capacities that it has activated. For every virtuality, or degree of power, there is an intensive range of affects 'bounded by two limits: the optimal limit...and the pessimal limit' (Deleuze & Guattari 1987: 257). Passing beyond these intensive limits in either direction will result in the deactivation of that virtuality.

When Deleuze and Guattari (1987: 257) write that 'we will seek to count [a being's] affects,' they are referring to the intensive changes that occur when it interacts with other intensive individuals. However, 'the sum total of [a being's] intensive affects' (Deleuze and Guattari 1987: 260) is bound by its set of capacities. By establishing a being's intensive limits, those affects that it cannot undergo, we also learn something about its virtuality.

Thus, the second cartographic principle is to count a being's capacities, its affects, and its intensive limits. Given that a being's capacities are actualized in collaborations with other beings that have corresponding capacities to affect and to be affected, a being's capacities can only be counted when it is interacting with others. Walking into a FabLab that is closed for the night will reveal little about its capacities. The strength of the ethnographic approach is that it allows the researcher to immerse him or herself in a being's intensive environment for a sustained period of time. He or she is able to witness the being in a variety of interactions, as well as interact directly with the being and its parts.

In this case, I spent a great many hours observing FabLabs in action to get a grasp of what they can do, what beings they interact with, and the affects those interactions produce in the beings involved. Granted, I did more than observe. In addition to the interviews I conducted, I would also ask people to show me rather than tell me, particularly when it came to what a lab's machines could do. I also participated in workshops and other lab activities, such as making furniture, cleaning, and greeting newcomers. For brief periods of time, I would become an active part of a lab, getting a direct glimpse of the effects that labs can have on their parts. Even when a lab is bustling with activity, there are many capacities that either go un-actualized, or manifest themselves in ways that the cartographer is not receptive to. Still, the best I can do as a researcher is to experiment with the capacities that I can access and attempt to build a receptivity to those that are currently beyond my grasp.

The third principle of cartography follows on from the second as it has to do with what happens when the intensive thresholds that correspond to a given virtuality are crossed. If every virtuality has optimal and pessimal intensive limits, then crossing those limits would results in its deactivation, and the activation of a new virtuality by a new intensive individual. A new being emerges with a whole new set of capacities. The third cartographic principle is to map the emergence of new beings, new intensive individuals and new virtualities. Not all emergences are the same. Steam emerges from water over a certain intensive threshold, but water can also emerge from steam under that threshold. There is a symmetry between water and steam that doesn't exist between tree and ash, for example. The cartographer has to be mindful of the symmetric or asymmetric quality of a new being's emergence.

The beings that concern my research project, mainly humans and digital machines, have a wealth of capacities that allow them to participate in the emergence of countless new beings, either as parts or efficient causes, but, given their vast sets of virtual capacities, it can be difficult to establish whether a newly activated capacity belongs to an existing human or machine, or if it should be attributed to an emergent being.

The fourth principle of cartography is that *non*-relations matter. There are a number of reasons why there might be a non-relation between beings. First, they can have incompatible capacities to affect and to be affected. There is a non-relation between a 3D printer and human speech because the former lacks the capacity to be affected by the later. Of course, it is entirely likely that 3D printers will eventually have this capacity to be affected by its user's voice in the future, but for now this incompatibility forces the human to communicate with the printer non-verbally. Another reason for a non-relation could be a lack of proximity. Simply put, things are too far apart to relate even if they have compatible capacities.

Non-relations can also be attributed to resistance, a topic I address in depth in chapter 5. Even the most willing subordinate cannot fully satisfy his master's desires because he cannot fully know them, but an actively recalcitrant subordinate can make things even more difficult for the master by creating non-relations. When an employee does not execute the command of her superior, she refuses to actualize a collaboration between her capacities and those of the objects she works with. The non-relation is not between her and her superior, but between her and those other agents the superior wanted her to mobilize. A strike is a collective refusal to actualize real capacities, thereby creating non-relations where relations are expected. This kind of resistance functions by obstructing or refusing to participate in another being's individuation or emergence.

It is crucial to bear in mind that refusal and obstruction are also part and parcel of the strategies that reproduce existing power relations. Anyone who has dealt with an insurance company will attest to their ability to refuse service or coverage for a claim made, but obstruction often manifests itself in other ways. Pay walls on websites, for example, block access to information, while many physical products are designed to prevent users from making alterations or repairs themselves, issues that I return to later. In this respect, resistance is an effective tool to block the formation of relations that are antithetical to the perpetuation of the status quo. It is imperative, therefore, that the cartographer not only identify non-relations, but also their causes.

The fifth principle of cartography is to remember that all beings are composites with parts that are themselves beings with their own capacities and affects. Untangling parts from wholes can be a challenge, but it is necessary to recognize the relative independence of parts, especially those that have the capacities to be a part of several wholes at once. In a FabLab, for example, people working on the same project will have very different ties to other institutions and concepts. One may be a student with educational commitments, another employed at a tech company and spending leisure time at the lab. It is this phenomenon of multiple belongings that makes cartography both challenging and well suited to the study of networks.

Finally, the sixth principle of cartography is to look for longer-term and larger-scale processes that have persistent and pervasive influence on the becoming and emergence of many beings. In the case of this research project, I argue that proletarianization is such a process, one that has impacted, and continues to impact, the becomings and emergences of human beings, social institutions, and technological objects alike. These processes tend to be more diffuse and move at a slower pace, but they are no less real. Much like a being exerts a downward causal pressure on its parts, they favour the activation of certain capacities over others, but also the emergence of certain beings and not others, as well as certain affects and non-relations. The challenge is to recognize these processes without turning them into totalizing structures that determine everything they touch.

To recap, the six cartographic principles that shape my methodology are:

i.Include the researcher as part of the territory to be mapped

ii.Count a being's capacities, its affects, and establish its intensive limits

iii.Chart the emergence of new beings

iv.Investigate non-relations

v.Remember that all beings are composites

vi.Identify long-term and large-scale processes

III. Navigating the FabLab Network

The challenge for all research is that the researcher is always constrained in his or her capacities to be affected. Fortunately, most researchers are able to activate new capacities, that is, to learn and become more receptive investigators. I came to this project with a very limited understanding of digital fabrication technology. In other words, my capacities to affect and to be affected were very different to those who had spent years working in FabLabs or other kinds of makerspaces. An important first step in my research was to familiarize myself with the technical terminology that abounds in these spaces. Fortunately, FabLab users tend to be extremely forgiving and generous when it comes to correcting mistakes.

Given that their stated mission is to democratize access to technology, FabLabs are highly receptive to newcomers. While every lab is different, they each have an inviting outward-facing side to them, necessary to recruit new members and spread the word about their activities. There was no suspicion of a researcher – a criminologist no less – asking for interviews, spending time in the lab, or attending lab meetings and other events. One could compare the general attitude of the people active in the FabLabs I researched to that of an evangelical religious community: strangers are warmly welcomed out of a mixed sense of goodness and obligation. In this respect, I did not encounter many of the challenges that ethnographers experience in trying to gain access to their research subjects.

Although my understanding grew over time, my general strategy whenever I visited a new lab was to act as an uninitiate (which wasn't very difficult), or at least request that they give me the same standard introduction that they would to someone who had never set foot in a FabLab. This was important to give me a sense of the strategies FabLabs use to appeal to prospective members, and note what information they felt was most essential to convey at the very beginning of someone's initiation. Most labs had a well rehearsed introduction that was designed to lay out the principles of a FabLab in general, and the specific application of those principles in this particular lab.

After going through the introduction, my *modus operandi* was to identify those members who appeared most invested in the lab and most receptive to my presence. Frequently, this would be the same person who gave the introductory tour, but not always. If local conditions allowed for it, I would conduct interviews or arrange for future interviews. A total of 20 semi-structured interviews were conducted with a variety of actors affiliated with European FabLabs, primarily in Paris, Hamburg, and Budapest. Interviewees consisted primarily of FabLab members and managers, but also included fellow researchers.

In addition to these interviews, I engaged in participant observation of the regular functioning of three FabLabs: Fabulous St Pauli in Hamburg, the Petit FabLab de Paris, and FabLab Budapest. I interacted with users and intrigued walk-ins, enquiring about ongoing projects, personal backgrounds and their motivations for being there. At the Petit FabLab de Paris, I contributed to the lab's operations where possible.

I also attended events held by FabLabs and partner organizations. At the end of August, 2016, Fabulous St Pauli hosted a conference on smart cities which consisted of a series of creative workshops over three days. Later that year, I attended a conference on ‘Fab cities’ at the Volumes makerspace in Paris. And in March 2017, FabLab Budapest organized the launch of FabLabNet, a new network of Central European labs, a full day event in the Hungarian capital. These events were significant, not only in the way they promote FabLabs to a wider audience, but also as occasions of debate between users on the role of FabLabs, past, present, and future.

Finally, my ‘net’nographic research consisted of visiting websites affiliated with the FabLabs I visited in person, and other sites designed to facilitate the sharing of information between labs. Most importantly, I went through the archives of the annual Fab Academy program offered at a number of sites across the world. Not only is the Fab Academy another important way in which the Fab network promotes itself to the outside, it is also an excellent source of information on the hardware and software available in most labs. The Fab Academy archives and other online platforms give FabLab members the chance to exchange ideas, tutorials, and design files to test and learn from.

Conclusion

This chapter outlined the cartographic method that informs this research project. Inspired by the works of Deleuze and Guattari, DeLanda, and Bryant, cartography is committed to mapping the reality and becoming of beings across different ontological registers so as formulate and respond to a problem. I used Deleuze and Guattari’s typology of book forms to highlight the differences between cartography and other kinds of research. I subsequently listed six cartographic principles that I used as guidelines throughout my ethnographic investigation. Lastly, I detailed the specifics of my time researching the FabLabs. In the following chapter, I turn to the issue of proletarianization, discussing different theories of proletarianization before offering my own understanding of the term, one that is heavily indebted to the works of Stiegler and Simondon. Only then am I able to offer an account of the extent to which FabLabs are sites of de-proletarianization.

3. The Problem of Proletarianization

Introduction

Having stated my ontological and methodological frameworks, I can finally address the problem at the heart of this thesis: proletarianization. The modern use of the term *proletariat* is attributable to Marx and Engels, for whom the proletariat is a socio-economic class that emerges at the onset of capitalism, along with its counterpart the bourgeoisie. In a footnote from the 1888 English edition of the *Manifesto of the Communist Party*, Engels (1978: 473) defines the proletariat as ‘the class of modern wage-labourers who, having no means of production of their own, are reduced to selling their labour power in order to live,’ and the bourgeoisie as ‘the class of modern Capitalists, owners of the means of social production and employers of wage labour.’ Based on these definitions, *proletarianization* refers to the expansion of the proletariat as a share of a society’s total population.

Nevertheless, the notion of proletarianization has since been given a variety of meanings, all of which have some footing in Marx’s extensive meditations on the proletariat. These subsequent interpretations differ according to the characteristics of the proletariat that they promote as essential. Even Stiegler (2011a), whose understanding of proletarianization is the most original, attributes his definition to a re-interpretation of Marx (via Simondon). It should come as no surprise, therefore, that Marx features heavily in this chapter as a source of insight and inspiration for my own understanding of proletarianization. That said, I make no secret of the fact that my definition is a clear departure from Marx’s description of the proletariat and other Marxist theories of proletarianization.

I define proletarianization as a process that weakens our individual and collective capacities to pose and respond to economic, social, and political problems. The main purpose of this chapter is to unpack this definition and clear the way for my analysis of the FabLabs as sites of de-proletarianization in the subsequent chapters. In section I, I discuss a variety of Marxist theories of proletarianization, particularly those found in the works of Marx and Engels themselves as well as the work of the 20th century American Marxist Harry Braverman. Rather than keep the discussion strictly theoretical, I include some empirical data which supports at least some of these theories. Next, I detail the important contributions made by Simondon and Stiegler to reignite the debate on the nature of proletarianization. Their reformulations serve as a crucial stepping stone to my own definition which I elaborate in the final section. Although my interpretation of proletarianization is unconventional, I argue that it resonates with the original Roman term *proletarius* and its resuscitation in the work of the British historian Arnold J. Toynbee (1934; 1939).

I. Marxist Theories of Proletarianization

The clearest early description of proletarianization is found in the *Manifesto of the Communist Party* (Marx & Engels 1978). Part history, part prophecy, Marx and Engels assert that the proletariat – the class of wage-earning labourers – would continue to grow as tradespeople and small business owners would be forced out of business either by their larger competitors or by technological advancements that made their skills obsolete. For fear of destitution, these formerly self-employed individuals would join the rest of the proletariat in their search for capitalists to whom they could sell their labour. According to this narrative, 'entire sections of the ruling classes are, by the advance of industry, precipitated into the proletariat' (Marx & Engels 1978: 481), until the disparity between bourgeoisie and proletariat is so acute that revolution is imminent. I call this the *hourglass thesis of proletarianization*.

If we take the proletariat to mean wage and salaried workers, regardless of income levels, then there is strong empirical data to support this thesis. For member countries of the Organization for Economic Co-operation and Development (OECD), the average of wage and salaried workers as a percentage of total employment stood at roughly 85 percent in 2015, according to the latest available data (World Bank 2017), up from 80 percent in 1991. In the United States of America, that percentage jumps up to 93 percent for 2016, up from 84 percent back in 1960. We might conclude, therefore, that Marx and Engels (1978: 480) were right in predicting a growing proletariat that recruits 'from all classes of the population,' however that would constitute a rather shallow victory for them and their sympathizers. Despite the massive size of the proletariat in all OECD countries, none seem poised for the kind of proletarian revolution that Marx and Engels had anticipated.

The *Manifesto* also suggests a second theory of proletarianization, one that can be traced back to Marx's *Economic and Philosophical Manuscripts of 1844*. While the hourglass thesis operates on a quantitative logic of macroeconomic indicators, i.e., the proletariat's share of a given population, the second theory of proletarianization has to do with the quality of the work performed. In the *Manifesto*, Marx and Engels (1978: 479) write:

> Owing to the extensive use of machinery and to division of labour, the work of the proletarians has lost all individual character, and consequently, all charm for the workman. He becomes an appendage of the machine, and it is only the most simple, most monotonous, and most easily acquired knack, that is required of him.

In addition to selling their labour to the owners of the means of productions, the proletarians perform tasks for their wages that are increasingly menial. Thus, a second theory of proletarianization would be one that, following Braverman (1974), I call the *degradation of work thesis*. Testing this thesis empirically is certainly more complicated than it was for the hourglass thesis of proletarianization, not least as it requires a qualitative analysis of the changes in how people have worked in various sectors, over multiple generations.

Against the degradation of work thesis, there are labour economists who argue that the majority of technological change is 'skills-biased,' meaning that it 'favours skilled over unskilled labour by increasing its relative productivity, and, therefore, its relative demand' (Violante 2008: 1). For instance, a 1999 report by the U.S. Department of Labor maintains that the '[d]emand for higher-skilled employees is a 50-year trend' (76). In the same report, the authors state that 'America does not face a worker shortage but a skills shortage' (USDL 1999: 6), an idea that continues to be promoted today. In an article for the MIT Technology Review, Kristin Majcher (2014) writes that the 'skills gap' in the U.S. 'could grow more acute in the next few years... by 2020, the United States could face a shortfall of 875,000 highly skilled welders, machinists, machine mechanics, and industrial engineers.'

When it comes to employment and education, the latest statistical data also appear to undermine the degradation of work thesis. Not only does the share of adults with a tertiary education continue to rise in OECD countries, university or college educated adults have higher rates of employment and higher incomes than those who only have a secondary school diploma or less (OECD 2017). All these indicators suggest that work is becoming more complex and stimulating, rather than simple and monotonous.

Be that as it may, to outright dismiss the degradation of work thesis would be to lack historical perspective. Although there is a case to be made that the technological developments of recent decades have favoured more educated and higher skilled workers, the technological and organizational changes that occurred during the 19th century in Europe and North America were biased toward unskilled labour. It was this earlier period of economic and technological transformation that informed Marx and Engels' theory of proletarianization as the degradation of work.

i. The Proletarianization of the Artisan

Prior to large-scale manufacturing and industrialization, the production processes in Europe and North America were primarily artisanal. An artisan is 'a craftsman who engages in the entire production process of a good, containing almost no division of labour' (Frey & Osborne 2017: 256). Artisans of the same craft would organize as guilds to control and regulate the quality and cost of the goods they produced in a particular location. Apprenticeships, the exclusive means of entry to a craft, were lengthy, ranging from five to nine years depending on guild regulations, to ensure that artisanal skills would be passed on from generation to generation, but also to restrict the number of competing artisans in a given market (Epstein 2008).

In *Capital Volume I,* Marx (1976) argues that the transition from artisanal to industrial production did not start with a change in technological capacities so much as an organizational innovation, namely, the division of labour. He calls *manufacture* the period of production between the artisanal guild system and industrial capitalism, characterized by the division of labour, the factory, and 'the differentiation of the instruments of labour' (Marx 1976: 460). Manufacture decomposes 'a handicraft into its different partial operations' (Marx 1976: 457) so that the tasks once performed by a single skilled artisan are now executed by several specialized workers. These specialized workers are 'special organs of a single working organism that only acts as a whole... the collective worker' (Marx 1976: 466, 468).

From the specialized worker's perspective, the repetition of 'the same simple operation for the whole of his life converts his body into the automatic, one-sided implement of that operation' (Marx 1976: 458). He is converted into 'an organ which operates with the certainty of a force of nature, while his connection with the whole mechanism compels him to work with the regularity of the machine' (Marx 1976: 469). It is with the division of labour and the specialization of work that manufacture has a de-skilling and degrading effect on labour.

One of the major repercussions of segmenting the labour process is that it creates workers whose specific function is so simple that it can be performed by anyone. Given that '[e]very process of production [...] requires certain simple manipulations, which every man is capable of doing [...] in every craft it seizes, manufacture creates a class of so-called unskilled labourers, a class strictly excluded by the nature of handicraft industry' (Marx 1976: 470). He adds that, '[if manufacturing] develops a one-sided speciality to perfection, at the whole of a man's working capacity, it also begins to make a speciality of the absence of all development' (Marx 1976: 470). The worker whose speciality is 'the absence of all development' becomes totally dependent on the availability of unskilled jobs, that is, on the unskilled jobs offered by the owners of the means of production.

The de-skilling process that started in manufacture is accelerated in the industrial era. If the former was defined by specialized workers operating specialized tools, the latter was characterized by the use of machinery, i.e., 'a mechanism that, after being set in motion, performs with its tools the same operations as the worker formerly did with similar tools' (Marx 1976: 495). Manufacture required the production of specialized tools designed to be manipulated by specialized workers; the tool had to be adapted to the worker. With the advent of machinery, however, the concern turns to the relations between machines. In lieu of manufacture's collective worker, industry is the era of the 'collective working machine' (Marx 1976: 502).

Thus, for Marx, the industrial revolution marked a great transfer of skill from the collective worker to the collective working machine. Workers lose their specialized tools and the skills needed to handle them as these are passed 'over to the machine' (Marx 1976: 545). Their 'muscular power' (Marx 1976: 517) is now mechanical power. The technical objects of production experience a surge in capacities as they are 'emancipated from the restraints inseparable from human labour-power.' No longer a tool bearer, the worker's education is simply to 'learn to adapt is movements to the uniform and unceasing motion of an automaton' (Marx 1976: 546):

> In handicrafts and manufacture, the worker makes use of a tool; in the factory, the machine makes use of him. There the movements of the instrument of labour proceed from him, here it is the movements of the machine that he must follow. In manufacture the workers are the parts of a living mechanism. In the factory we have a lifeless mechanism which is independent of the workers, who are incorporated into its living appendages.
>
> (Marx 1976: 548)

More important than the worker's gradual loss of skill to the machine, were the ways in which manufacture and industry enacted the 'separation of the intellectual faculties of the production process from manual labour, and the transformation of those faculties into powers exercised by capital over labour' (Marx 1976: 548). The true source of work's degradation has less to do with a loss of skill, than with a loss of control over the process of production. The ability to invent, design, and construct an object that once belonged to the artisan, is now fragmented into manual and mental tasks performed by labour and capital respectively.

ii. Braverman and the Degradation of Work

Nearly a century after Marx's *Capital,* the degradation of work thesis was reinvigorated by Braverman in his 1974 work *Labour and Monopoly Capital: The Degradation of Work*. Braverman's goal was to update Marx's analysis of work for the 20th century and, in so doing, challenge the notion that 'Marxism was adequate only for the definition of the 'industrial proletariat,' and that with the relative shrinkage of that proletariat in size and social weight, Marxism, at least in this respect, has become 'outmoded''(Braverman 1974: 13).

Like Marx, Braverman (1974: 25) defines the proletariat, or the working class, 'as that class which does not own or otherwise have proprietary access to the means of labor, and must sell its labor power to those who do.' However, he argues that, in late 20th century America, 'when almost all of the population has been placed in this situation so that the definition encompasses occupational strata of the most diverse kinds, it is not the bare definition that is important but its application' (Braverman 1974: 25).[5]

For Braverman (1974: 114), the degradation of work results from the generalized application of 'the principle of *separation of conception from execution*' (Braverman 1974: 114) which concentrates all decision-making and control over the labour process in the hands of capital. 'Not only do the workers lose control over their instruments of production,' he writes, 'but they must now lose control over their own labour and the manner of its performance' (Braverman 1974: 116).

Braverman argues that the tendency to strip workers of their agency that Marx had identified in the early industrial factory was intensified with the development of scientific management by the likes of Frederick Taylor and Frank Gilbreth. The purpose of this new science 'was never... to enhance the ability of the worker, to concentrate in the worker a greater share of scientific knowledge, to ensure that as technique rose, the worker would rise with it ... [but rather] to cheapen the worker by decreasing his training and enlarging his output' (Braverman 1974: 117-118). By breaking down the labour process to the most minute detail, scientific management sought to curtail the little that was left of labour's control over the production process.

What is more, Braverman saw the same process at play in the organization of office work. Although one of the early effects of scientific management was an increase in the complexity of managerial and clerking tasks, office work also underwent a period of fragmentation where a hierarchy of middle managers and office clerks was put in place to perform specialized administrative functions. These 'white collar' workers did in fact require higher levels of literacy and numeracy than their 'blue collar' counterparts, but 'the mechanization of the office' (Braverman 1974: 351) ensured that the vast majority of them were bound by the same rigid controls as those put in place on the factory floor. The principle of separation of conception and execution persists in the office, resulting in 'a mounting dissatisfaction with the conditions of industrial and office labor...[as] work has become increasingly subdivided into petty operations that fail to sustain the interest

5 Whereas roughly 'four-fifths of the population was self-employed in the early part of the 19th century' (Braverman 1974: 53), the rate of self-employment in the U.S. currently stands at around ten percent (Bureau of Labour Statistics 2016).

or engage the capacities of humans with current levels of education' (Braverman 1974: 3-4).

Against the idea that 'the changing conditions of industrial and office work require an increasingly 'better-trained,' 'better-educated,' and thus 'upgraded' working population' (Braverman 1974: 424), Braverman's overarching claim is that the growing sophistication of production processes in general does not imply an appreciation in the quality of work that capital makes available to labour. Instead, the opposite is true:

> The mass of workers gain nothing from the fact that the decline in their command over the labor process is more than compensated for by the increasing command on the part of managers and engineers. On the contrary, not only does their skill fall in the absolute sense (in that they lose craft and traditional abilities without gaining new abilities adequate to compensate the loss), but it falls even more in a *relative* sense. The more science is incorporated into the labor process, the less the worker understands of the process; the more sophisticated an intellectual product the machine becomes, the less control and comprehension of the machine the worker has. In other words, the more the worker needs to know in order to remain a human being at work, the less does he or she know.
>
> (Braverman 1974: 425)

And contrary to the 'skills gap' claim, Braverman notes the arbitrary assignment of labels such as 'skilled,' 'semi-skilled,' and 'unskilled' labour. Rather than correspond to any specific set of capacities, these categorizations are always made from the perspective of capital: '[t]he worker may remain a creature without knowledge or capacity, a mere 'hand' by which capital does its work, but so long as he or she is *adequate to the needs of capital* the worker is no longer to be considered or called unskilled' (Braverman 1974: 447).

iii. Job Polarization and Technological Unemployment

More than four decades after Braverman's analysis, the needs of capital have become increasingly digital. The technological innovations broadly referred to as automation and computerization have prompted two interconnected economic trends: job polarization and technological unemployment. By job polarization, economists refer to the declining share of middle-income jobs, and the growing share of high-income and low-income employment in North America and Western Europe (Goos &

Manning 2007; Goos et al. 2009; Autor & Dorn 2013; Goos et al. 2014). While some of this 'hollowing out' is attributed to the offshoring of jobs to countries with cheaper labour costs, it is primarily due to the fact 'that recent technological change is biased toward replacing labor in routine tasks (what we call routine-biased technological change (RBTC)' (Goos et al. 2014: 2509). Office clerks, trade and craft workers, plant and machine operators and assemblers, have all decreased as a share of total employment thanks to technological innovations that can perform the same routine tasks more efficiently and at a lower cost.

These findings run contrary to the idea of skill-biased technological change which would 'lead one to predict a uniform shift in employment away from low-skilled and toward high-skilled occupations' (Goos et al. 2009: 58). They also support a third thesis of proletarianization: the *thesis of involuntary downward social mobility.* According to this thesis, proletarianization is the middle-class becoming the working-class, in the sense of lower wages and greater job insecurity. The data on job polarization and the continued growth of low-income jobs as a share of total employment suggests that this kind of proletarianization is indeed occurring, even if it is offset somewhat by the continued growth in high-income jobs. The question, however, is how long will those low-income jobs continue to grow?

In a 2017 article entitled 'The Future of Employment: How susceptible are jobs to computerisation?', Carl Benedikt Frey and Michael Osborne estimate that 47 percent of total U.S. employment is at high risk of being computerized or automated in the coming decade or two. They argue that advances in machine learning, mobile robotics, and big data will allow nonhumans to perform a lot of the tasks currently performed by human workers, many of whom are considered 'skilled' in official labour statistics. Therefore, Frey and Osborne (2017: 269) predict 'a truncation in the current trend towards labour market polarisation, with computerisation being principally confined to low-skill and low-wage occupations.' Whether this leads to mass technological employment will depend on how these increasingly automated economies change over time (Kim et al. 2017).

In this section, I have gathered three theses of proletarianization: the hourglass thesis that posits a growing share of wage and salaried workers in an economy; the degradation of work thesis which sees proletarianization as the separation of conception and execution and the loss of worker control over the production process; and, finally, the involuntary downward social mobility thesis where middle-income workers gradually sink into precarious low-income jobs. All three proposals have Marxist roots. The most original and relevant of these is the degradation of work thesis, as it links proletarianization to labour's weakened ability to pose problems at work: what is produced, how it is produced, and why. The separation of conception and execution means that only the owners of the means of production or their delegates in management are able to pose, and respond to, problems. The organization of labour and the formation of socialist parties were notable efforts to redress this imbalance, but their success has only ever been limited and their futures uncertain. The following section shifts our attention to the theories of proletarianization found in the works of Simondon and Stiegler, theories that reformulate the problem of proletarianization in terms of the relations between humans and technology.

II. Proletarianization as a Technological Problem

If Marxism frames proletarianization as a process driven by the class struggle between the bourgeoisie and the proletariat, Simondon and Stiegler argue that the true dynamic of proletarianization is found in our relations to technological objects. In many respects, Simondon and Stiegler follow the same historical trajectory as Marx and Braverman, starting with the transition from artisanal to industrial production in the Global North. The main difference, however, is that Simondon (1989: 117) and Stiegler argue that proletarianization, or 'the alienation captured by Marxism as having its source in the worker's relation to the means of production, is not solely attributable to...a property relation or non-property relation.' Given that Stiegler builds on Simondon, I start with the latter's contributions to the question of proletarianization.

i. Simondon's Technical Individual

Although Simondon never uses the term *proletarianization*, his work is no less relevant. However, in order to understand his relevance to the issue of proletarianization, first we must get a basic grasp of Simondon's philosophy of technology. In *On the Mode of Existence of Technical Objects*, Simondon (1989) addresses what he perceived to be a growing rift between culture and technology, human and machine. Like Marx, he pinpoints the 19th century and the emergence of industrial machinery as the moment when the relations between humans and technology became problematic. It was during that period that machines replaced humans as ‘technical individuals,’ a notion that has a very specific meaning in his philosophy of technology. For Simondon, there are three levels of technology: elements, individuals, and ensembles. Technical ensembles are composed of technical individuals that are composed of technical elements, but the main difference between these levels has to do with how they relate to their surroundings.

A technical individual is a durable assemblage of elements that is co-constituted with an ‘associated milieu,’ i.e., a surrounding environment that allows the technical individual to function sustainably. The associated milieu ‘is both technical and natural’ and it is ‘that through which the technical being conditions itself in its functioning...it mediates the relations between the fabricated technical elements and the natural elements in which the technical being functions’ (Simondon 1989: 57). The technical individual both conditions and is conditioned by an associated milieu that is unique to it alone. The associated milieu regulates the technical individual through a feedback loop that prevents it from undermining its own integrity when it functions. Elements do not have their own associated milieus and are not, therefore, self-regulated. Only once they are embedded in a technical individual do elements function sustainably, much like our own biological organs (Simondon 1989: 65).

Lastly, ensembles gather technical individuals in such a way that each individual is able to maintain its associated milieu. Thus, ‘the creation of a single associated milieu is undesirable for an ensemble... [and] it utilizes certain strategies to fight against this possibility’ (Simondon 1989: 63). A FabLab, for example, would be considered an ensemble because it gathers a number of machines in one place and ensures that the functioning of one machine does not undermine the functioning of another.

Prior to the industrial revolution and the tool bearing machine, artisans were the sole technical individuals, with their tools as elements and their workshops as associated milieus. After industrialization, however, the status of technical individuality belonged to the machine, and the worker was effectively reduced to one of its elements. Simondon considers this transition to the root cause of the tension between culture and technology:

> there is a malaise because man, still wanting to be a technical individual, no longer has a clear role next to the machine: he becomes a servant to the machine or an organizer of the technical ensemble; and for the role of human to have any meaning, each employee must have a holistic understanding of the individual, its elements, and its role in the ensemble.
>
> (Simondon 1989: 81)

In order to get over this malaise, Simondon argues that we need a new technical culture that accepts the machine as technical individual and teaches us how to interact with all technological levels of technicity, so that what we lose in technical individuality we recover in the new possibilities to develop ourselves with machines. Hence, the problem is not that machines have replaced humans as the new technical individuals, but that industrial societies have failed to provide their people with a technological education that would allow them to engage with their increasingly technological milieu, to meaningfully participate in its evolution, and transform themselves in the process. Instead, industrial societies have systematically excluded the vast majority of people, and the vast majority of workers, from technology's evolutionary process, a process which has largely been determined by the preeminent principle of capital accumulation. Here, we have Simondon's first important contribution to the question of proletarianization, namely, that the proletariat is excluded from the genesis of technology at a time when nonhuman technical individuals are drastically reshaping their societies.

Simondon's analysis complements Marx and Braverman's degradation of work thesis of proletarianization: not only are workers stripped of theirs skills and control over the production process, they are also unable to contribute to technology's development. Work in the industrial factory is an inadequate way of relating to technology because 'the worker acts on the machine without advancing the activity of [technological] invention through his actions' (Simondon 1989: 249). Where Simondon differs from Marx and Marxists, however, is on capital's relation to technology. Although the owners of the means of production can determine the ends to which machines are used and influence their development, they too remain ignorant of the technical reality they ostensibly control, for 'to own a machine is not to know it' (Simondon 1989: 252). For Simondon, '[c]apital and labour are two modes of being that are equally incomplete in relation to the technical object and the technicity of industrial organization' (Simondon 1989: 118).

In strategic terms, Simondon argues contra Marx that the 'collectivization of the means of production cannot reduce alienation by itself; only if it were the precondition for human individuals to acquire the intelligence of the technical individual object' (Simondon 1989: 119). While he acknowledges that 'non-possession increases the distance between the worker and the machine at work' (Simondon 1989: 252), the question of ownership must be superseded by the question of technological knowledge. Such knowledge 'consists not only of using a machine, but also a certain degree of attention to the technical functioning, maintenance, regulation, and improvement of the machine, which extends the activity of invention and construction' (Simondon 1989: 250).

ii. The Consumerist Relation to Technology

Simondon's second contribution to the question of proletarianization shifts the focus from the sphere of production to that of consumption. If the worker is proletarianized at work by not being able to participate in the technological evolution of the means of production, the consumer is proletarianized by a consumerism that devalues the technological aspects of consumer products. According to Simondon, the consumerist relation to technology formulates the wrong problems and questions. Instead of asking how a machine works or how it might be improved, the consumer asks how much it costs, what it can do, and, in many cases, he will evaluate the social implications of owning machine *x, y,* or *z*.

By emphasizing an object's social attributes over its technical qualities, consumerism distracts from the machine's technical merits, not to mention its potential as an ally of social, individual, and ontological transformation. Machines are sold as symbols of status, social accessories that are 'made to be seen rather than to be used' (Simondon 2009: 23). Consequently, machines can become socially obsolete well before they deteriorate functionally. On the side of production, market pressures on manufacturers to make a profit shift their priorities away from the machine's durability, to its social attributes.

Simondon also reproaches consumerism for encouraging people to see technological devices as impervious to modification. A product is marketed and bought as a whole that could not be better (in its price category, of course):

> judged once and for all, accepted or rejected in full in the decision or the refusal to buy, the object of industrial production is a closed object, a false organism that is seized by a holistic thought that was psycho-socially produced.
>
> (Simondon 2009: 24)

Consumerism and marketing treat objects holistically, leaving the consumer disconnected from the technical composition that is the machine, an expression of a 'rich reality of human efforts and natural forces' (Simondon 1989: 9).

In a sense, Simondon makes a claim analogous to Marx's theory of the commodity fetish. Marx (1976) argues that the commodity-form conceals the true sources of value, i.e. labour, and thus the exploitation of workers by the owners of the means of production. The product of labour assumes the commodity-form when it is brought to market and given a monetary value, at which point it can be compared to all other available commodities by price. Rather than consider the specific social characteristics of an item's production, the consumer considers an item's price. And because money is a standardized medium of exchange, a commodity's price is presented as an objective evaluation of its value by the market. For Marx (1976: 168), this means that the 'determination of the magnitude of value by labour-time is therefore a secret hidden under the apparent movements in the relative values of commodities.' What is actually the outcome of inequitable social relations between people in the realm of production, is falsely attributed to relations between things in the realm of exchange. Hence, Marx (1976: 163) calls this false attribution of value to the commodity itself 'the fetishism of the commodity' comparable to religious fetishisms where inanimate objects are believed to have supernatural powers.

Of course, Marx and Simondon argue very different cases: one claims that the object conceals a wider social reality, while the other says that the social context distracts from the object's technological reality. These claims are not mutually exclusive; in fact, they compliment each other. Both Marx and Simondon identify the distance between production and consumption as a source of their respective concerns. The fetishism of commodities 'arises from the peculiar social character of the labour which produces them':

> Objects of utility become commodities only because they are the products of the labour of private individuals who work independently of each other... Since the producers do not come into social contact until they exchange the products of their labour, the specific social characteristics of their private labours appear only within this exchange.
>
> (Marx 1976: 165)

Similarly, Simondon argues that consumers are so far removed from the production process that they are only receptive to the object's cost and social qualities, those aspects of the object that are visible at the point of purchase. Consequently, 'the buyer – who is neither a constructor nor a user in act – the human being who chooses, introduces into his choice a bundle of non-technical norms' (Simondon 2009: 23). Ultimately, the proletarianization of the producer is intertwined with the proletarianization of the consumer, neither of which are able to participate in the evolution of the technical beings that increasingly structure all aspects of their lives. It is on this point that Stiegler builds on Simondon to develop his theory of proletarianization.

iii. Stiegler's Theory of Proletarianization

Proletarianization is for Stiegler 'the process through which an individual or collective knowledge, being formalized through a technique, a machine, or an apparatus, can escape the individual – who thus *loses* this knowledge which was until then *his* knowledge' (Ars Industrialis 2010, emphasis in original). From this condensed definition, we can already gather that proletarianization involves a loss of knowledge, but only from the perspective of the human individual whose knowledge has being 'formalized.' Contrary to Marx, Stiegler's proletarian is 'not defined by the absence of ownership over the means of production but by a loss of knowledge' (Dillet 2017: 80).

Stiegler argues that 'the proletariat has never been reducible to the working class' (2011b: 104), but that the artisans and craftsmen in pre-industrial Europe were the first victims of proletarianization because they lost their knowledge and know-how (*savoir-faire*) in the manner described by Marx (1976) in *Capital,* first to the division of labour in manufacture, and then to industrial machinery. The artisan's gestures are dissected into discrete actions that can be repeated *ad nauseum* by a specialized worker or machine. Stiegler (2010a: 10) refers to any such process of discretization as 'grammatization.' While grammatization does not imply proletarianization, all proletarianization appears to presuppose grammatization. The alphabet, for example, is a result of the grammatization of language, which allows for the spatial and temporal transmission of thought. For grammatization to lead to proletarianization, the human individual must lose the knowledge that she held in its fluid, non-grammatized, form. In the case of the pre-industrial artisan, he would have lost his knowledge in one of two ways: either by falling out of practice himself, or by being unable to pass on his skills to an apprentice.

Another way Stiegler (2015: 57) describes proletarianization is as an 'exteriorization without a return, that is to say without an internalization.' Thought in these terms, grammatization is the exteriorization of knowledge into distinct units, or *grammes,* that can be replicated by humans or machines. Proletarianization occurs when machinic replication eliminates the need for human replication and, by extension, the need for humans to re-internalize the knowledge that has now been formalized in the machine. A simple but familiar example of this phenomenon would be how smartphones have eliminated the need to memorize telephone numbers, including our own.

In fact, Stiegler sees memory as central to proletarianization, a relation that he argues Plato was the first to theorize in his *Phaedrus*. In that dialogue, Phaedrus and Socrates discuss the effects of writing on human memory. Socrates argues that, as exteriorized memory (*hypomnesis*), writing undermines the practice of internal memory (*anamnesis*), and therefore leads to '*a loss of memory and knowledge*' (Stiegler 2010a: 30, emphasis in original). Plato becomes the first philosopher to argue that a technology, in this case writing, proletarianizes its users. According to Stiegler (2010a: 35), there is a clear link between Plato's *Phaedrus* and Marx's analysis of capitalism:

> we discover that the Platonic question of hypomnesis constitutes the first version of a thinking of proletarianization, insofar as it is true that the proletariat are those economic actors who are without knowledge because they are without memory: their memory has passed into the machine that

> reproduces gestures that the proletariat no longer needs to know – they must simply serve the reproductive machine and thus, once again, they become serfs.

The response to proletarianization, however, cannot be to prevent the exteriorization or grammatization of knowledge. If grammatization is a pre-condition of proletarianization, it is also a pre-condition of learning and knowledge transmission. 'Grammatization is *irreducibly* pharmacological' (Stiegler 2010a: 42, emphasis in original), the *pharmakon* being that which is both a poison and a cure. When one person's knowledge and know-how is exteriorized and grammatized, it becomes collective knowledge, available for others to internalize through a process of learning, but it can just as easily be formalized in a machine or apparatus that can discourage internalization. Whether grammatization produces toxic or curative effects, proletarianization or learning, largely depends on the social, political, and economic context in which it is distributed.

Unfortunately for the artisan and his prospective apprentice, the grammatization of his gestures led to technological innovations that enabled early capitalists to make his know-how obsolete, and did not open new possibilities of learning to compensate for this loss. Since then, Stiegler argues that nearly all occupations, no matter their socioeconomic standing, have undergone a similar process. Their knowledge and know-hows have been 'absorbed by hypomnesic processes consisting not only in machines, but in apparatuses, expert systems, services, networks, and technological objects and systems of all kinds' (Stiegler 2010a: 39). This process includes professionals, academics, and so-called cognitive workers who Stiegler claims are in the process of losing their theoretical knowledge (*savoir-théoriser*), just as skilled manual labourers lost their know-how (*savoir-faire*). If the latter are '*proletarians of the muscular system,*' the former are '*proletarians of the nervous system*' (Stiegler 2010: 45, emphasis in original).

All the while, Stiegler (2010a: 35) argues that another process of grammatization and proletarianization was ongoing, this time affecting '*consumers who [were] henceforth deprived of memory and knowledge by the service industries and their apparatuses*' (emphasis in original). The proletarianization of the consumer, which results from 'the grammatization of perception and of the nervous system,' destroys what Stiegler (2010: 42) calls *savoir-vivre*, which translates somewhat awkwardly into knowing-how-to-live. The combined loss of know-how (*savoir-faire*), *savoir-vivre*, and theoretical knowledge (*savoir-théoriser*) constitutes a state of generalized proletarianization, the defining condition of contemporary Western societies according to Stiegler.

Our historical moment is also characterized by the grammatization of all knowledge and know-how into digital information that is extremely transmittable and transformable. For Stiegler, digital technology is the *pharmakon* around which the political contestations of the 21st century will revolve. Although he maintains that its toxic and proletarianizing effects have prevailed thus far, Stiegler also sees in the digital *pharmakon* the potential for a new economy built on de-proletarianization, which is to say an economy that promotes learning and voluntary contribution. He points to the free software movement as an important example of what such an economy could look like.

Importantly, to promote learning is not the same as to encourage people to acquire institutional accreditation or skill certification. For Stiegler, learning involves both an internalization of knowledge by the individual learner *and* a transformation of the learner's milieu. Learning is not strictly acquisitive, nor individualistic, but requires the production of positive externalities in a shared milieu which he calls an 'associated *sociotechnical* milieu' (Stiegler 2010a: 51, emphasis added), an expansion of Simondon's concept of an associated milieu that includes human individuals and nonhuman technical individuals. Against proletarianization, i.e., exteriorization without internalization, de-proletarianization or learning consists of a virtuous cycle of internalization and exteriorization. In the following chapter, I argue that this logic of learning is being implemented by FabLabs with varying degrees of success.

There is a great deal of continuity between Stiegler's theory of proletarianization and the degradation of work thesis proposed by Marx and Braverman. Both theories take the fragmentation, or grammatization, of the artisan's labour process as the precondition for the decline of meaningful labour and the ascent of capitalism. They also agree that the use of machinery in the production process exacerbated the inequality between capital and labour. And most importantly, there is a shared recognition that workers are degraded by being unable to participate in the direction and evolution of their work.

What Stiegler offers over and above Marx, or Braverman, is an understanding of proletarianization that grants technological beings an ontological independence which makes them *pharmaka* for labour *and capital*. Despite the fact that capital has had almost 'full control over technological becoming' (Stiegler 2010a: 82), technology is never fully subservient to capital, and carries within it the seeds of different social and economic configurations. Moreover, Stiegler argues that the tendency to grammatize and formalize knowledge into technological objects and technical systems is so pervasive that it has proletarianized the representatives of capital themselves, leaving them just as proletarianized as the rest of us.[6] Thus, he regards proletarianization as a process that isn't subservient to capital's interests, even if it has largely benefited those interests historically.

Stiegler and Simondon open the problem of proletarianization well beyond its Marxist formulations. They point to our relationship with technology as both part of the problem and part of the response to proletarianization. Furthermore, they regard proletarianization as a problem that extends beyond the realm of production, to include consumption and other facets of social existence. In the next section, I develop my own definition of proletarianization that builds on these insights, while drawing on the Roman origins of the term *proletariat*.

III. Proletarii: New and Old

I argue that proletarianization is a process that weakens our individual and collective abilities to pose and respond to economic, political, and social problems. Like Marx and Braverman, I consider this process to be intertwined with a capitalist economic system that tends to separate the conception and execution of tasks at work. Following Stiegler and Simondon, I also recognize the technological aspect of this problem which extends beyond the realm of production. That said, what does it mean to be able to pose and respond to economic, political, and social problems?

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6 Stiegler (2010a) uses the example of Alan Greenspan, former chairman of the U.S. Federal Reserve, who admitted in his testimony to congress after the 2008 financial crisis that their over-reliance on technological systems was part of the reason why they had failed to anticipate the event.

On a basic level, to pose a problem means to bring a set of conditions into relation. In mathematics, the simplest problems typically involve two conditions: given the numbers x and y, what other numbers can emerge from their interactions (addition, subtraction, multiplication, division)? Setting the values of x and y determines the solutions those interactions will produce. When it comes to economic, political, and social problems, the same logic applies even if the number of conditions increases dramatically. Instead of integers, these problems have every kind of being – human and nonhuman – as their conditions. What beings are counted as conditions and which are excluded will strongly influence a problem's solution. As a consequence, whoever sets a problem's conditions tends to set its solutions.

Historically, the setting of economic, social and political problems has been a highly exclusive process: there are those who have a say in what a problem's conditions should be, and those who can only feature as conditions, if at all. Political structures, both formal and informal, are built on this dichotomy, some having more distributed problem setting mechanisms and others are more centralized. The same applies to economic problems, such as *what to produce?*, *how?*, or *how much?*.

A student of Roman law, Marx's inspiration for the term *proletariat* is the latin *proletarius* (*proletarii* plural) which was the lowest class designation for Roman citizens in Ancient Rome. The *proletarii* were 'citizens of Rome too poor to contribute anything to the state except their children (proles)' (Lintott 2016). That the *proletarii* were '[m]en without property...[who] had not even the minimum property required for the lowest class' (Berger 1953: 657) explains why Marx would repurpose this term for modern wage-earners in 19th century Europe who had little to no private property, save their children. But, whereas Marx chose to emphasize the *proletarii*'s lack of property, I am more interested in what was their limited ability to participate in the political and military life of Rome at the time. In other words, what concerns me is what they could not *do*, rather than what they did not *have*.

Lower in status than even the lowest of the plebeians, *proletarii* had severely limited voting rights in the *Comitia centuriata* (Centuriate Assembly), which itself had restricted legislative functions. At the end of the regal period and in the first half of the Roman republic, the *proletarii* were awarded 1 of 193 centuries in the *Comitia*, a century being a voting block that was originally composed of 100 delegates

(Abbott 1901: 21). A reform to the *Comitia* in 241BCE exacerbated that disparity by increasing the total number of centuries to 373, keeping the sole century for the *proletarii* (Abbott 1901: 75). The *proletarii* were also excluded from the military, only called upon in 'in the case of a *tumultus*, a serious threat to the safety of Italy' (Roselaar 2009: 612). Unlike the plebeians who successfully mobilized at times to gain concessions from the upper classes, the *proletarii* were practically excluded from the political and economic evolution of Roman society.

Thus, when I define proletarianization as a process that weakens our abilities to pose and respond to societal problems, I am appealing to this historical lineage of the term *proletariat,* and I am not the first to do so. In *A Study of History*, the 20th century British historian Arnold Toynbee (1934: 41) makes extensive use of the term, qualifying that '[t]he word 'proletariat' is used here and hereafter in this Study to mean any social element or group which in some way is 'in' but not 'of' any given society.' He adds,

> it is used in the sense of the Latin word *proletarius* from which it is derived. In Roman legal terminology, *proletarii* were citizens who had no entry against their names in the census except their progeny (*proles*)...To say that 'proletarians' contribute nothing to the community but their progeny is a euphemism for saying that the community gives them no remuneration for any other contributions that they may make (whether voluntary or under compulsion) to the common weal. In other words, a 'proletariat' is an element or group in a community which has no 'stake' in that community beyond the fact of its physical existence.
>
> (Toynbee 1934: 41)

A proletarian, according to Toynbee, is a non-stakeholder, someone who is excluded from its political, economic, and social life.

To be clear, by drawing these connections between the *proletarii*, Toynbee's proletariat, and my definition of proletarianization, I am *not* arguing that our contemporary circumstances have deteriorated so dramatically that we are no better off than the average *proletarius* of Ancient Rome. For all its limitations, representational democracy in Europe and North America has given the majority of its citizens a greater role in the process of problem formulation than at any other time in history. And despite its antipathy toward democracy in the workplace, capitalism did bring about a significant de-centralization of economic activity when compared to the institutions of feudalism.

The sources of proletarianization today are completely different and far more subtle than they were for the *proletarii* or the various minority groups that Toynbee (1934; 1939) refers to as proletarians. Although there are still remnants of elitist political structures and discrimination against minority groups, I argue that the main contemporary source of proletarianization is a widespread inability to problematize the technological conditions of society. To problematize the technological conditions of society has a dual meaning in this context. On the one hand, it means to include technological beings as conditions in a problem. On the other hand, it also means to treat technological beings as problematic, not in the sense of troubling or dangerous, but in the sense of an open problem with multiple internal and external conditions that can engender a variety of responses.

The problem of proletarianization is that we are unable to properly formulate problems that are increasingly technological in nature. An accelerated rate of technological change over the past three centuries has meant that virtually all political, economic, and social problems have more technological conditions than ever before, conditions that we are societally ill-equipped to grasp and problematize. In this respect, my understanding of proletarianization is deeply indebted to the works of Simondon and Stiegler who pinpoint the technological nature of this process. However, instead of a loss of knowledge or know-how that has been formalized in a machine, proletarianization is more aptly described as a failure to learn from the machine. Proletarianization is not a zero-sum game between humans and technology, but a vicious cycle that can be turned virtuous.

In terms of the capacities-based ontology presented in chapter 1, proletarianization is marked by a poor cultivation of human capacities that are compatible with technological capacities. As a result, the intensive interactions between most humans and technological beings are constricted, even if the number of such interactions in our daily lives continues to grow. Thus, when it comes to formulating problems, we are persistently failing to include relevant beings and capacities as conditions to those problems and, ultimately, as parts of their solutions. To complicate matters further, technological beings now exist on scales that are difficult for human beings to grasp sensorially, whether it is the Internet's vast network or the microchip's tiny processor, making them easier to ignore. A process of *de*-proletarianization should therefore include the cultivation of human capacities that allow us to first recognize technological capacities and, second, interact with them in more ways than we are currently able. It is for this reason that the FabLabs and the maker movement present themselves as potentially significant forces of de-proletarianization.

Conclusion

In this chapter, I provided an overview of the various theories of proletarianization, from Marx to Stiegler. In so doing, I gathered a number of insights that inform my own definition of proletarianization which revolves around the ability to pose and respond to economic, political, and social problems. Drawing on the Roman origins of the term *proletariat,* I sought to explain why my understanding warrants the name *proletarianization* despite its notable departure from its Marxist counterparts. Having insisted on the technological nature of proletarianization, the following chapter looks at this relationship more closely, the role of invention in a process of de-proletarianization, and how the FabLabs practice invention.

4. FabLabs and The Politics of Invention

Introduction

At its core, proletarianization is a problem of capacity cultivation and distribution. Our success as a species in creating so many artificial beings with incredible capacities has inadvertently left us in a set of circumstances that we struggle to problematize. Not only are we unable to include technological beings as conditions to our collective problems, we also have difficulties approaching technology as a problem in and of itself. This predicament is troubling for the simple reason that *the political is technological*. In making such a claim, it is imperative that we avoid the pitfalls of technological determinism and social constructivism. The issue is not to establish whether technology determines politics, or vice versa, but to investigate how humans and technological objects engage in what I call a *politics of invention*.

I broadly define invention as the activation of new capacities and new virtualities. When a newly activated capacity belongs to a technological being, I call this *technological invention*. If, instead, the new capacity belongs to a human being, that invention is called *learning*. The politics of invention consists of the dynamics between technological invention and learning, how these two types of invention affect each other's respective evolution. The current state of this politics, I argue, is a major contributing factor to proletarianization. For most humans, technological invention and learning are largely disconnected, limited to learning how to actualize a new technological being's capacities.

Nevertheless, there are enclaves where a different politics of invention is practiced, one that attempts to create a virtuous cycle between technological invention and learning. In this chapter, I examine the development of this alternative politics of invention in European grassroots FabLabs. Drawing on my ethnographic study of labs in Budapest, Hamburg, and Paris, I argue that the ways in which FabLabs practice invention are de-proletarianizing because they enable people to simultaneously problematize technology and learn.

Structured in three parts, I start with a theoretical discussion of the concept of invention, focusing on the works of the Simondon and the French philosopher, sociologist, and criminologist Gabriel Tarde, before detailing my own definition of invention. Simondon and Tarde both highlight the problematic nature of invention which relates the concept directly to my understanding of proletarianization. In section II, I outline a historical overview of the FabLabs and the maker movement, as well as their connections to the free and open source software movement. This sets the scene for section III where I explore the ways in which FabLabs are developing a different politics of invention and the de-proletarianizing effects of those practices.

I. Invention in Theory

When one thinks of invention, the tendency is to conjure images of famous inventors and great figures of history who transformed the world with their creations. For Gabriel Tarde, however, sociology is the study of far more modest inventions that propagate across society by imitation. 'Socially,' he argues, 'everything is either invention or imitation' (Tarde 1903: 3). The more an invention is imitated, the greater its impact on a given society.

i. Tarde's Invention and Imitation

Living as he did in a period when the wave theory of light was established science, Tarde bases his social theory of invention and imitation on wave interaction. A society is interlaced with a multitude of imitative rays that originate in moments of invention. As is the case with lightwaves in physics, when two imitative rays interact they either create constructive or destructive interference. For Tarde (1903: 43), invention is 'the timely intersection in one mind of a current of imitation with another current which re-enforces it' (Tarde 1903: 43). A mind is needed to synthesize two imitative waves into an invention.

Tarde, however, is not an anthropocentric thinker; a mind is not necessarily a human mind. Instead, he writes of 'cellular inventions, cellular industries, and cellular arts,' which make him question 'whether it is really certain that our own intelligence and will, those great *egos* disposing of the vast resources of a gigantic cerebral state, are superior to those of the tiny egos confined in the minuscule city of an animal or even plant cell' (Tarde 2012: 22). Thus, Tarde's concept of invention isn't simply sociological, it is also ontological.

What remains to be understood is why certain inventions are imitated more than others. According to Tarde (1903: 45), inventions are likely to produce strong imitative waves when they 'answer the problems of the time...for every invention, like every discovery, is an answer to a problem.' He adds,

> problems, inasmuch as they are themselves the vague expressions of certain indefinite wants, are capable of manifold solutions, the point of interest is to know how, why, and by whom they have been raised.
>
> (Tarde 1903: 45)

Here, Tarde touches directly on the problem of proletarianization. For every invention, the challenge is to determine what problem the invention responds to.

ii. Simondon and the Problem's of Technological Invention

Simondon also emphasizes a link between inventions and problems. Like Tarde, he argues that an invention is a response to a problem. When faced with a problem, a being has a variety of strategies at its disposal. To illustrate this point, Simondon employs the straightforward example of a boulder blocking a walking path. Confronted with this obstacle, a hiker can either take a detour or amplify her force production by using an existing instrument at her disposal, asking other people for help, or, lastly, fashion a device out of available material. Technological invention is therefore but one of a variety of possible responses to a problem. The difference with technological invention, however, is that the resulting technological object is itself a problem.

In fact, technological objects always imply two kinds of problems. The first and more familiar problem is an object's integration into an environment that precedes its existence. The technological object is 'a mediator between an organism and an environment...it must adapt to the heterogeneous terms that it relates, and it is an aspect of its progress to better its ties to the realities between which it builds a bridge' (Simondon 2005: 101). This problem has to do with how an object interacts with other beings, whether it successfully mediates relations between different beings, and whether it has other unforeseen effects on its environment.

The second kind of problem that the technological object poses is less apparent because it relates to its internal coherence between parts and functions. For Simondon, it is this internal dynamic that drives technological evolution. He calls ‘concretization’ the process by which ‘objects are simplified by assigning a plurality of functions to each of its [internal] structures’ (Simondon 2005: 286). A technological object evolves by reducing the number of separate elements, or internal structures, necessary to perform the same number of functions. Technological invention is therefore driven, on the one hand, by the desire to resolve tensions between an object and the external terms it mediates, and the desire to resolve tensions that exist in an object’s internal structure between its parts on the other hand.

Of these two kinds of problems, the tendency in sociology has been to address the first and ignore the second. The underlying assumption is that technology is only truly ‘social’ when it mediates relationships between human actors. Therefore, the sociologist should only be concerned with a technological object’s ‘external’ relations, and leave the ‘internal’ relations to engineers and computer scientists.

Another tendency is to focus exclusively on the social context in which an object is invented. A predominant example of this tendency is the social construction of technology (SCOT) school of thought which treats human-made artifacts as a site of conflict between competing human interests (cf. Pinch & Bijker 1984). From a SCOT perspective, a technological object’s capacities are determined by the resolution of a political struggle between human parties who have a vested interest in *x, y, z* functionality. The recent debate over cellphone encryption backdoors clearly illustrates this kind of political dynamic that can centre around technological objects.

The SCOT approach is certainly not without merit. It is very important to understand the politics of technology and the interests that influence an object’s production and functionalities. In fact, I would argue that the FabLabs – and the wider Maker movement – play a crucial role in highlighting the political dynamics that flow through the technical devices we interact with on a daily basis. Nevertheless, confining one’s analysis in this way poses a number of practical and ontological problems.

Ontologically, it denies the technological object and its parts their independence vis-à-vis human beings. There are always material limitations, dictated by the productive capacities available at a given time and place, that bear on what technological objects are possible to produce. Consequently, human interests are necessarily constrained by the capacities of the tools and materials at their disposal, a rather obvious point, but one that gets eclipsed when construction is described as purely 'social.'

On some level, an object always surprises its inventor(s). Given that the object 'surpasses expectations[,] it would be partially false to say that invention is done to achieve a goal, to realize an effect that was entirely predictable in advance; invention responds to a problem, but an invention's effects surpass the resolution of that problem' (Simondon 2005: 288-289). The problem sets invention in motion, but the invented object does not only resolve a problem, it alters the conditions that gave rise to the problem in the first place. Chain reactions can form where the resolution of a problem gives rise to a whole new series of problems.

Practically, there are a number of problems with excluding the technological object's internal dynamics from sociological consideration. First, those relations that make an object work are the result of a long history of interactions between humans, and between humans and nonhumans. There is a social history of technological invention that is embedded in each part of an object, not just in the finished product as a whole. Part of the rift between culture and technology is caused by forgetting that '[w]hat resides in machines, is human reality, human gestures fixed and crystallized into functioning structures' (Simondon 1989: 12). There is also a wealth of capacities and information residing in technological objects, which brings me to a second practical problem.

By ignoring the technical aspects of technology, sociologists reinforce the very division of labour that is at the heart of proletarianization. The technical capacities and information crystallized in the machine has a social and political value. Left to a select group of professionals and academics, that social and political value drops significantly. In the worst case scenario, technical knowledge is used to advance certain interests in rather deceptive manners: online trackers used to gather data on user activity without express notification, or the ability to remotely turn on someone's webcam or computer microphone. Technological illiteracy facilitates this kind of abuse of technological power.

Still, the problems with technological illiteracy extend beyond a vulnerability to unwanted control or intrusion. Granted, there are very good reasons to be concerned about such abuses of power, and criminologists have an especially important role to play in bringing these issues to light. However, such a focus tends to overshadow the less dramatic realization that the vast majority of people know very little about the technology around them because technological education is not an important part of a general education in most Western societies. For Simondon (1989: 14), expanding our understanding of mass education to include technological instruction 'could offer man the means to think his existence and his situation in relation to his surrounding reality.' Hence, the fundamental issue is the disconnect between humans, their increasingly technological milieu, and the technical reality embedded in each object.

Again, the problem for Simondon is not that humans have been replaced by machines as the new technical individuals, but rather that humans do not understand the technological object. Simply regarding machines as faithful embodiments of human intentions violates a number of ontological and strategic principles. Above all, it fails to grasp the problematic nature of objects and the fact that they are partial resolutions to the tensions between other objects that have their own capacities. In the process of invention, humans must treat technological objects as composites of objects, looking beyond the constructed whole to the capacities of its parts and their parts in order to discover new configurations, and invent new objects. Treating objects as problematic means acknowledging that they are not perfect which is how they appear to us under the prevailing consumerist relation.

iii. Technical Mentality, Open and Closed Objects

Against this status quo, Simondon (2009) argues that invention requires a *technical mentality*. The overarching aim of this mentality is to develop a relation between human and machine 'that has a doubly genetic function, for humans and for machines, whereas [in other theories], machine and human were already entirely constituted and defined at the moment of their encounter' (Simondon 2007: 278). Rather than treat humans and technical objects as finished products, a technical mentality starts from the premise that both terms are open to transformation, each with their respective evolutionary processes. Stronger still, these genetic processes are intertwined such that humans transform technology, and technology transforms humans.

Technical mentality starts with the postulate that '*subsets are relatively detachable from the whole of which they are a part'* (Simondon 2009: 19, emphasis in original). A technological object is not 'an absolutely indivisible organism that is metaphysically one and indissoluble' (Simondon 2009: 19), it is a composition of subsets that retain a degree of independence vis-à-vis the whole. Thus, the human endowed with a technical mentality is able to recognize the latent potential, the virtual capacities in an object's parts that are the seeds of invention.

Once an object is treated as the partial resolution of a tension between the objects that compose it, each defined by a set of capacities, Simondon (2014) argues that it is possible to differentiate between *open* and *closed* objects. As is the case with the vast majority of commercial products, the closed object is 'completely new and valid when it first comes out of the factory, and then, it enters a kind of aging period, it loses status, it degrades, even if it isn't used...because it has lost contact with contemporary reality, on account of its closed nature' (Simondon 2014: 401). The closed object starts to degrade as soon as it is finished because it wasn't designed to evolve in step with new technological developments.

In contrast, the open object is designed to be maintained and altered in such a way that its aging is slowed to a minimum; it can continue to 'progress with technological developments' (Simondon 2014: 402). An open object materializes the principle of technical mentality that subsets are relatively independent of the whole they compose. It should be alterable, repairable and designed to prevent obsolescence (Simondon 2009).

The distinction between open and closed objects also suggests two contrasting politics of invention. At the beginning of this chapter, I stated that the politics of invention consists of the dynamics between technological invention and learning. Technological invention consists of the activation of new capacities that belong to a technological object, while learning is the equivalent for human beings. An open object facilitates learning by allowing us to explore the ways in which its parts fit together and, more importantly, by allowing us to recognize that we affect its internal configuration, given the right information and practice. This constitutes a virtuous politics of invention, where technological invention leads to learning, and vice versa.

iv. Learning

If learning is a form of invention as well, it is in part because it too is a response to a problem. Simondon (2007) argues that learning is a strictly organic form of invention. Humans, for example, differ from machines primarily in their respective capacities to pose problems. Calculating machines can solve equations, but they cannot problematize their own existence, that is, they cannot include themselves as terms in the problems to solve. The axioms that govern a machine's operations are never problematized by their expression. Thus, Simondon (2007: 273) argues that machines have 'questions to solve, not problems.' For humans, however, their governing axioms can be problematized by changes to their environment. Unlike machines, humans are receptive to stimuli that are not automatically compatible with their internal structures which, as these stimuli become more frequent and intense, can provoke structural adaptations. Simondon (2007: 273) calls this adaptive process learning.

Crucially, learning is an intensive process. Quantitative changes in information can lead to qualitative changes in an organism's structures and capacities at critical thresholds:

> This characteristic of discontinuity, this *existence of thresholds* does not hold for the automaton, because the automaton does not change structure; it does not incorporate acquired information into its structure; there is never an incompatibility between its structure and the information it acquires because its structure determines in advance what kind of information it can acquire; thus, the automaton never confronts problems of integration, but only the question of storing information that is by definition integrable...
>
> (Simondon 2007: 273)

It is at these critical thresholds that the individual's internal structure becomes so problematic that it must change into a new structure that integrates the accumulated information. Learning is only made possible by the individual's 'open ability to acquire information, even if that information is not homogenous in relation to its current structure' (Simondon 2007: 273). When unfamiliar information becomes problematic, the human individual is able to consider itself a part of the problem, a variable that may need to change in order to resolve the problem. The onus does not fall exclusively on the unfamiliar to make itself palatable to our current capacities to be affected.

Given our state of proletarianization, we are starting to lose our distinction from the automaton. Instead of problems, we are left with questions. Instead of learning, we consume familiar information which confirms our current ideas and opinions. All the while, the problems accumulate with conditions that we are unable to recognize or affect. In the following section, I provide an overview of a phenomenon which offers a different politics of invention that could contribute to a process of de-proletarianization: the FabLabs and the maker movement.

II. A Brief History of the FabLabs

The FabLabs started as an outreach project by the Center for Bits and Atoms (CBA) at the MIT. With a sizeable grant from the National Science Foundation (NSF), a U.S. government agency that supports research in the sciences, Professor Neil Gershenfeld set up a 'fabrication laboratory' at the CBA in 2001. The lab was to be the site of Gershenfeld's graduate level course, 'How to Make (almost) Anything,' as well as act as a space for research and development in digital fabrication technologies and practices. Gershenfeld's stated intention was to train students who could assist him in his longstanding project: to build machines that can assemble at an atomic level. As its name suggests, the CBA is dedicated to bridging the gap between computer science and the physical sciences, between digital bits and atoms. The CBA's motto (of sorts) is 'to turn things into data, and data into things' (Gershenfeld 2012: 44), and as the centre's director, Gershenfeld was looking for researchers from various disciplinary backgrounds to join his cause. The fabrication laboratory would serve as a meeting point for those researchers as well as teach them how to design, program, and make machines and materials.

To his surprise, Gershenfeld's course attracted as many artists and architects as engineers and computer scientists. According to Gershenfeld (2005), these students were motivated 'by the desire to make things they'd always wanted, but that didn't exist,' or what he refers to as 'personal fabrication.' The NSF's original grant also required that the CBA develop some outreach projects for the benefit of the wider community. Given the success of Gershenfeld's course, the decision was made to set up fabrication laboratories, or FabLabs, in communities with limited access to digital fabrication technology. At the end of 2003, The first FabLab outside of the CBA was set up at the South End Technology Center (SETC) in Boston's inner-city. With a price tag of $70,000, the SETC lab had more modest capabilities than the CBA's lab, but it nevertheless proved to be a success in offering access to digital fabrication tools and a basic education in how to use them for the residents of a disadvantaged community. One of the important lessons from the SETC experience was the importance of giving control of the lab's operations to local activists with ties to the community.

After the SETC lab, the CBA had no other outreach plans, but a Ghanaian immigrant community in Boston's South end lobbied the CBA to set up a FabLab in the coastal town of Sekindi-Takoradi in Ghana, which it did in 2004 thanks to yet another NSF grant. The CBA went on to sponsor labs in Costa Rica, Norway, rural India, and Afghanistan. Between 2004 and 2017, the number of self-identified FabLabs shot up to at least 1,200 worldwide.[7] Crucially, the vast majority of the increase can be attributed to labs that were set up independently of the CBA. There is no single explanation for this exponential growth in the number of FabLabs, but there are some clear contributing factors.

The first factor was Gershenfeld's book, *FAB: The Coming Revolution on your Desktop – from Personal Computers to Personal Fabrication*, published in 2005. Given the handful of labs that the CBA had already set up at that time, Gershenfeld was able to show some of the practical impact that FabLabs could have in various social and economic contexts around the world. His main argument was that the biggest limiting factor on the spread of personal digital fabrication was not technical capability or financial cost, but 'simply the lack of knowledge that [it] is even possible' (Gershenfeld 2005), a rather misleading claim given the tens of thousands of dollars the CBA had spent on each lab.

Nevertheless, the book served the purpose of spreading the word about FabLabs and the possibilities of digital fabrication for personal and communal use. *FAB* also coincided with the launch of *Make* magazine by Maker Media, the self-proclaimed

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7 A running tally can be found at https://www.fablabs.io/labs

voice of the maker movement that continues to publish bi-monthly issues to this day, in print and online. The following year, Maker Media organized the first Maker Faire in Silicon Valley to inaugurate the start of the movement.

i. The Maker Movement

Chris Anderson (2012: 21), the former editor-in-chief of *WIRED* magazine and current CEO of 3D Robotics, claims that the maker movement is defined by three characteristics: (i) the use of digital desktop tools to design new products, (ii) the 'cultural norm to share designs and collaborate with others in online communities,' and (iii) the 'use of common design file standards.' In short, makers tend to design digital objects (data) that can be turned into material objects (things), and they tend to share their data with others. The FabLabs and other makerspaces grew as local gathering points where makers could try to turn their or other people's data into things using digital fabrication tools that they could not afford to own or access otherwise.

The concept of a community workshop, or a shared machine shop, predates the maker movement. Smith (2014) recalls the brief existence of Technology Networks in London between 1983 and 1986, 'community-based workshops [that] shared machine tools, access to technical advice, and prototyping services, and were open for anyone to develop socially useful products.' Ultimately, the movement and the Technology Networks withered in the neoliberal climate of Thatcher's Britain.

In 1995, c-base was set up in Berlin as the first self-proclaimed 'hackerspace,' i.e., a shared space for hackers to work. Hackers, it is worth restating, are people who write their own computer code, not inherently nefarious or malicious actors as the label is commonly understood. In the case of c-base, the focus was on developing free and open source software, as well as creating free public wireless internet networks. While it is tempting to state that hackerspaces are to the free and open source software movement what makerspaces are to the maker movement, it would also be wrong. Given that hackers need little more than a computer and an internet connection to participate in the production of software, there is less of a need for shared workspaces or the pooling of resources to acquire relatively expensive machinery. Hackerspaces like c-base were therefore geared towards more politically motivated hackers who sought to organize and work on projects that could address local needs.

Today, there are many makers and hackers that see no daylight between a hackerspace and a makerspace. Over time, hackerspaces started to include tools for the production of electrical circuits and other hardware. As personal computers became more affordable, hackers have taken to disassembling and reassembling computers to modify and repurpose them, or simply learn more about them. This growing focus on hardware makes most hackerspaces visibly indistinguishable to makerspaces. However, others argue that differences persist between hackerspaces and makerspaces. For Cavalcanti (2013), 'hackerspaces largely focused on repurposing hardware, working on electronic components, and programming' whereas makerspaces are designed to maximize the number of 'different types of craft spaces,' as well as allow users to design and make an object from scratch. Importantly, he also notes that hackerspaces tend 'towards collectivism, and radical democratic process as a method for making decisions,' while makerspaces are usually 'structured along the lines of traditional businesses' (Cavalcanti 2013). These differences notwithstanding, the number of makerspaces and hackerspaces only truly started to grow in the first decade of the 21st century.

ii. The Rise of Fab

Of the newly minted makerspaces, many elected to call themselves FabLabs despite having no affiliation to the CBA or Gershenfeld, especially in the Netherlands (Troxler 2015: 74). The CBA sponsored labs did not so much create the maker movement as provide a particular template for makers to emulate and run with as they saw fit. The sudden proliferation of non-CBA-affiliated FabLabs transformed what had started as an outreach project into a viral phenomenon that Gershenfeld rightly recognized as beyond his or anyone else's control. Still, in 2009, Gershenfeld and Sherry Lassiter of the CBA set up the Fab Foundation 'to facilitate and support the growth of the international fab lab network as well as the development of regional capacity-building organizations' (Fab Foundation). The Fab Foundation helps organize annual 'Fab' conferences, the first of which took place in 2005 when there were only thirty-two FabLabs, as well as administer the 'Fab Academy' program, a multi-site educational program that teaches the fundamentals of digital fabrication. Participation in the Fab Academy costs roughly five thousand euros per enrolee, a price tag that many FabLab members find excessive and exclusionary, although all of the course materials and video tutorials are made available online for free.

By 2009, the number of FabLabs had grown significantly, the majority of which were outside of the United States. In Europe, labs were set up in Amsterdam, Utrecht, Barcelona, Vestmannaeyjar (Iceland), and Høylandet (Norway), in addition to the original CBA sponsored lab in Lyngen (Norway). The Fab Foundation, mindful that policing the network would be both impractical and unpopular, made the modest demand that all makerspaces that refer to themselves as a FabLab abide by the Fab Charter, which reads as follows:

> *What is a fab lab?*
>
> Fab labs are a global network of local labs, enabling invention by providing access to tools for digital fabrication
>
> *What's in a fab lab?*
>
> Fab labs share an evolving inventory of core capabilities to make (almost) anything, allowing people and projects to be shared
>
> *What does the fab lab network provide?*
>
> Operational, educational, technical, financial, and logistical assistance beyond what's available within one lab
>
> *Who can use a fab lab?*
>
> Fab labs are available as a community resource, offering open access for individuals as well as scheduled access for programs
>
> *What are your responsibilities?*
>
> *safety:* not hurting people or machines
>
> *operations:* assisting with cleaning, maintaining, and improving the lab
>
> *knowledge:* contributing to documentation and instruction
>
> *Who owns fab lab inventions?*
>
> Designs and processes developed in fab labs can be protected and sold however an inventor chooses, but should remain available for individuals to use and learn from
>
> *How can businesses use a fab lab?*

> Commercial activities can be prototyped and incubated in a fab lab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs, and networks that contribute to their success
>
> (CBA 2012)

All the FabLabs that I visited as part of my research display the Fab Charter as a visible sign of solidarity with the Fab network. As the number of labs grew, so too did the number of interpretations of the charter. In a sense, the charter was designed to accommodate the widest possible range of lab structures, but tensions persist around the questions of public access and commercial activities. Many makerspaces decided not to refer to themselves as FabLabs, erroneously thinking that a FabLab had to be free to the public at all times, much like a public library. In reality, each lab chooses how much time they reserve for free public access, with most settling on a single afternoon or evening block per week. The rest of the lab's operating hours are typically reserved for paying members or scheduled workshops with educational partners ranging from elementary schools, to institutions of tertiary education.

The question of business access is also settled differently by each lab. On one side of the spectrum, labs like the Petit FabLab de Paris discourage businesses from using the lab not by prohibiting it explicitly, but by creating a lab culture that is ill-suited to those users who would prioritize efficiency over community. On the other side of the spectrum, Fab Lab Berlin promotes itself to the city's many start-ups as a cost effective place to prototype products. The degree to which a lab is open to business depends primarily on their capacities, lab culture, and how they finance their operation.

For many labs to stay afloat financially, they offer pay-for-services – 3D printings, engravings, prototyping – to individuals and businesses alike. Of the labs I researched in depth, FabLab Budapest had the most sophisticated business outreach, even managing to procure contracts from big industrial companies. Meanwhile, the Petit FabLab categorically refused all requests for paid services, pointing prospective clients to other Parisian labs that could meet their needs. Finally, Fabulous St Pauli offers pay-for-services, but lack the capacities to cater to more sophisticated needs. All three of these configurations are acceptable within the broad confines of the Fab Charter.

Perhaps the most important factor in the proliferation of FabLabs and other makerspaces was the plummeting cost of digital fabrication tools. Not only did market forces exert a downward pressure on hardware prices, open-source initiates such as the RepRap project created rapid prototyping machines that could be assembled in a FabLab. Those labs with limited capital could build their own machines, thereby reducing the initial investment to form a FabLab from tens of thousands of euros, to as little as five thousand euros. In 2011, Harman Zijp of FabLab Amersfoort in the Netherlands wrote 'The Grassroots FabLab Instructable,' a brief document that details 'how to set up a FabLab in 7 days with 4 people and about €5000.' While a FabLab has likely never materialized with such efficiency, Zijp nevertheless captured the real sense that a lab did not need institutional support, nor a prohibitive amount of capital, to come into existence.

The growing number of 'grassroots' labs – FabLabs with no direct affiliation to the CBA or another educational institution – has had a number of effects on the global FabLab network. Above all, it pushed the CBA and the Fab Foundation to revise its 'inventory of core capabilities' to account for labs of fewer means. Although there are grassroots labs that are equal to university hosted labs in terms of capabilities and initial investment, the majority tend to start with much less than the hundred thousand dollars that it costs to set up a FabLab with the CBA approved inventory of equipment. Today, FabLabs are broadly categorized between 'hosted' labs, which have institutional support from a university or other permanent sponsor, and grassroots labs that have to fend for themselves financially, be it via pay-for-services, membership fees, donations, or government grants.

The FabLab network continues to expand with a roughly equal share of hosted and grassroots labs. The Fab Academy program is training its 10th cohort and the 14th international FabLab Conference will take place in France in the summer of 2018. All indications suggest that the FabLab network will maintain its current growth rate, doubling its numbers every year and a half (Gershenfeld, Gershenfeld & Gershenfeld 2017).

III. FabLab Anatomy

A FabLab is a being composed of human and nonhuman beings. In accordance with my capacities-based pluralist ontology, a FabLab, like all beings, is defined first and foremost by its capacities to affect and to be affected, capacities that emerge from the interactions between its parts. Meanwhile, the lab exerts a 'downward causal influence' (DeLanda 2016: 18) on its parts that affords certain interactions and discourages others. Hence, we must tread carefully to distinguish those capacities that belong to the lab as a whole, and the capacities of its parts.

Every lab has its own unique collection of constituents. Nonetheless, because of their commitment to a shared set of technical capabilities, as well as a proclivity for labs to imitate each other, there are recurring beings in nearly all the labs that I researched: desktop computers, tables, chairs, 3D printers, laser cutters, vinyl cutters, micro-controllers, internet routers, wires, cardboard, wood, CNC mills, plastic polymers, and, last but not least, humans. Given that each one of those parts is itself a composite, an exhaustive list of all the beings that compose a FabLab is practically unfeasible. Instead, the purpose of a cartography is to map out those important power relations, i.e., relations between capacities, that allow us to navigate a specific problem which, in this case, is the extent to which FabLabs are sites of de-proletarianization.

The first, rather obvious, cartographic consideration is that FabLabs are enclosed spaces. With this spatial enclosure comes the need to manage a finite amount of space, relatively fixed actual relations between floors, walls, ceilings, windows, and doors that selectively cut off the lab from a spatial exterior and an intensive outside. It is therefore possible to think of a FabLab as a machine that acts on inputs and produces outputs, some of which are exchanged with the outside. A lab's main inputs are electricity, gas, water, broadband internet, digital data, people, primary materials, and air, as FabLabs need to be well ventilated. In terms of outputs, a FabLab produces physical artefacts, digital renditions of those artefacts, physical trash, digital trash, fumes, memories, emotions, and new capacities.

Identifying a FabLab's inputs and outputs is less important than understanding how it transforms one into the other. Here, it is necessary to consider how a lab is organized socially and materially. In terms of human actors, a lab relies primarily on one or several *fab managers*, that is, people who are competent and confident enough to open the lab to members or the public and mainly ensure that everything is working. A fab manager should also respond to any issues that may occur during their time overseeing the lab, as well as answer the questions of curious visitors who are unfamiliar with FabLabs. That said, a fab manager is not an instructor, meaning that they are not there to teach people how to do things beyond the bare basics of connecting machines and turning them on and off. Most managers tend to spend their time working on their own projects or chatting with newcomers rather than assisting or instructing the people already using the lab.

How somebody becomes a fab manager varies from lab to lab. At Le Petit FabLab de Paris, the status is granted informally by an acting fab manager, unless overruled by other members. Fabulous St Pauli has a more restrictive policy, due to the rather constant presence of one of the lab's founders who also works from the lab. Finally, FabLab Budapest is the most restrictive because it has the most business-like organizational structure, with paid employees and a central figurehead who makes all the executive decisions. In all circumstances, the fab manager does not actually manage the lab's users, as would a manager in most commercial enterprises.

FabLabs are political entities of a specific kind: they largely operate along the principles of voluntary action, association and contribution. Even though many labs charge membership fees in exchange for more regular access, all users are free to do what they please without having to report to anyone else. This freedom to choose what to do is diametrically opposed to the employer-employee relationship, whereby the former can impose tasks on the latter in exchange for a wage. The division of labour, as well as the clear separation of conception and execution for a given action, does not assume the same form in a FabLab as it does in business, but this is not say that they do not exist at all.

The process of making something in a FabLab involves a division of labour between humans and machines. Human actors have the capacity to initiate a project, to conceptualize an object that they would like to create. That said, these actors are bound by the capacities of the machines at their disposal. As a consequence, it is important from a cartographic perspective to understand what those machines can do, their capacities to affect and to be affected. I will focus on the three main pieces of equipment in most labs, namely, the 3D printer, the laser cutter, and the CNC mill.

i. 3D Printers

The technical ability to produce physical three dimensional models from digital models by adding layer upon layer of a given material has been around since the 1980s. Whereas most production processes are *subtractive* because they involve cutting desired shapes out of a material, such as wood, metal, or stone, 3D printing is an *additive* process that builds an object by binding small amounts of matter together until they assume the desired form and dimensions. Nearly all 3D printers consists of a bed, i.e., the surface upon which the object is printed, an extruder that deposits the material on the bed, filament of the material (usually some type of plastic), a heater cartridge to melt the filament and make it malleable, a fan to cool down the deposited layers, and a motherboard that controls the extruder's movements and communicates with other computers.

Thought of in terms of inputs and outputs, a 3D printer takes electric energy, digital data, and plastic materials, and transforms them into solid objects, air currents of various temperatures, and fumes containing ultrafine particles of the filament material used. Given that the fumes emitted by a 3D printer are harmful when inhaled, albeit to varying degrees depending on the type of filament, rooms containing 3D printers must be properly ventilated in the interest of human health. FabLabs must therefore be mindful of where they place their 3D printers and sensitive to the airflow surrounding them, all the while ensuring that the room's temperature doesn't undermine the printer's ability to heat and cool the filament as it works. All of these intensive parameters must be taken into consideration so as to manage the relationship between human and machine.

In order to 3D print an object, one starts with a digital model of the object created on a CAD program, of which there are many, both proprietary and open source. For first time users, it can be as simple as searching for and downloading a file of whatever looks interesting, opening the file in a software application called a 'slicer' which converts the design file into a set of digital instructions that the printer's motherboard can process. There are many online repositories of free 3D model files, such as thingiverse.com, grabcad.com, and pinshape.com, where makers post their digital models for others to download, alter, or simply replicate. Much of the external data entering a FabLab comes from these platforms. Many repositories, such as pinshape.com and myminifactory.com are also online marketplaces that allow people to buy and sell 3D printable models and designs, suggesting one way that the activities that occur in a FabLab could be monetized.

After the initial enthusiasm of discovering all of the millions of weird and wonderful objects people have posted as digital files, the next surprise to hit most first time printers is how long it takes to print something. Even the smallest of jobs – say your average plastic bottle cap – will take at least an hour with the kind of low to mid-level printers that most grassroots FabLabs can afford. The time needed for a job depends on the parameters set, the desired definition, and the infill density, i.e. the material density of an object's interior. The greater the density, the stronger and more resistant the object, and the longer the print time. 3D printers are also referred to as rapid prototypers, but that is only in relation to industrial scale manufacturing processes that can take days or weeks to produce a physical model. For the average maker, 3D printing is a lesson in patience.

The 3D printer's pace has important ramifications for a FabLab. This is especially true for labs such as Fabulous St. Pauli and le Petit FabLab de Paris that only have one functional 3D printer available to users. Realistically, neither of these labs can do more than four prints a day and small ones at that. FabLab Budapest has a much greater capacity, with ten printers available. Regardless of the number of printers, all projects that involve 3D printing have periods of prolonged waiting, freeing people to take an interest in the activities of others in the lab. In all cases, there is a downward causal pressure to limit print times so as to avoid hogging the machine. As a consequence, the printed objects tend to be weaker and less resistant, thus less durable and functional.

Fortunately, 3D printing is but one aspect of digital fabrication and what happens in a FabLab; all activity does not grind to a halt when the printer is busy with a job. That said, 3D printers are the most recognizable and appealing digital fabrication machines in a FabLab, particularly for those who are new to digital fabrication and the FabLab concept. There is certainly something awe inspiring about a 3D printer at work. It evokes a science fiction like future of mechanized and automated production that is bound to be disruptive both socially and economically in unpredictable ways. FabLabs draw on this seductive power of the 3D printer to bring more people into the community, even while many experienced makers disapprove of what they consider to be an exaggerated amount of public excitement over 3D printing.

As it stands, people in the FabLabs that I researched use 3D printers primarily to make fun figurines, miniature 3D renditions of famous sculptures, or the plastic frame for a fidget spinner. Far more rarely do people use the printers to create a replacement part for an appliance or to actually prototype an idea for future development. This is not say that 3D printers are inconsequential machines, but those found in grassroots FabLabs do not pose an immediate threat to more conventional manufacturing processes. Still, 3D printers do afford people the opportunity to experiment with plastics and witness the potential of additive manufacturing.

One of the most important projects to emerge from the 3D printing community is the RepRap project spearheaded by Adrian Bowyer, formerly of the University of Bath. Short for 'replicating rapid prototyper,' a RepRap is a 3D printer that was 'designed to be able to print out a significant fraction of its own parts' (Bowyer et al. 2011: 177). The aim of the project was to create a mechanical being that adopted certain biological strategies for reproduction, specifically the mutualism between flowers and insects. The bee, for example, is essential to the pollination of many flowers, a service that it performs in return for the pollen and nectar integral to its survival. In the case of RepRap, a similar mutualism would be sought with humans:

> It was designed to make its own parts to be assembled by people into another RepRap. The people would be driven to do this by the fact that the machine, when not reproducing, could make them all manner of useful products. It seemed (and still seems) likely that this would lead to a mutualist relationship between people and the machine that would inherit some of the longevity and the robustness of the evolutionary stable strategies of the insects and the flowering plants.
>
> (Bowyer et al. 2011: 180)

So as to further facilitate its reproduction, the initial RepRap designers made all of the blueprints and CAD files freely available and licensed the content under a General Public License (GPL), a copyright license which forces subsequent iterations of the CAD files to remain free source. Together these strategies have proven very successful. From the four RepRap machines that existed in 2008, there were at least 4,000 in 2011, and several times that amount today. New versions appear regularly, driven largely by contributions made by RepRap community members on online fora and the project's wiki, making the RepRap an excellent example of a democratizing and de-proletarianizing sociotechnical undertaking.

The RepRap project demonstrates that the peer-to-peer production models that were essential to free and open source software could also be used towards the creation of free and open source hardware. The RepRap is also a critical machine that draws attention to the fact that nearly all commercial products are not designed to perpetuate themselves as freely as possible. Instead, commercial products tend to be designed to discourage their reproduction by actors who do not serve the original producer's profit interests, such as competitors and customers. The exception to this rule are companies that sell open-source products, many of which have emerged from the RepRap project. Such companies will either sell assembly kits or provide auxiliary services. For the most part, however, profit-seeking companies rely on making their products sufficiently scarce that market prices and marginal returns remain high.

From my interviews and participant observations, FabLab users commonly praise the RepRap project as proof of the productive potential of the maker movement and the promise of free and open source hardware. Yet, only two labs of the three labs I studied in depth (Fabulous St Pauli and Petit FabLab) had RepRap machines on site and, in both cases, the machines were not operational. In the case of Fabulous St Pauli, the main 3D printer is an Ultimaker, an open-source company that spun off of the RepRap and FabLab community. At the Petit FabLab, they mainly use a Zortrax printer, Zortrax being a fully proprietary company based in Poland. Finally, FabLab Budapest has an arsenal of 3D printers made by CraftBot, a Hungarian proprietary company. This goes to show that equipment decisions in a FabLab are not solely based on whether a 3D printer is open-source or proprietary.

ii. Laser Cutters

A FabLab's laser cutter is yet another key tool for digital fabrication. Whereas 3D printers are an example of additive manufacturing, laser cutters are definitively subtractive machines. As the name suggests, a laser cutter cuts with a laser. For those who have never seen one in person, a laser cutter is a big box-like machine that opens up onto a work bench where materials can be loaded for cutting and engraving. Above the bench, there is a head that runs across two mobile axes. The head emits a laser beam, which is effectively a highly concentrated stream of light (photons) that can cut through certain materials and engrave others. The laser works on the chosen with such high precision that it is able to achieve what would be impossible to do by hand with conventional carpentry and engraving tools.

Like a 3D printer, a laser cutter is equipped with a small and basic computer that controls both the beam's movements and its intensity. The laser cutter's motherboard also allows it to communicate with other computers from which CAD files can be sent. In order to laser cut something, one starts by creating a digital design on a vector graphic design software application, some of which are free and open source, such as Inkscape, while others are proprietary and costly. AutoCad, for example, cost over a thousand euros to subscribe for a year. As it is with all digital fabrication, the bulk of the skill required to make things with a laser cutter consists of knowing how to use a CAD software application, that is, how to model things digitally in such a way that the laser cutter produces the desired finished physical product.

Using a laser cutter also requires a fair bit of knowledge about the materials to be cut or engraved. In practice, this means spending a lot of time experimenting with materials and the intensity of the beam. The laser cutter's capacity to cut or engrave must be paired with a corresponding capacity to be cut or engraved to achieve the desired result. Most laser cutters, for example, cannot cut metals, but they might engrave them. Other materials can be cut or engraved but, in so doing, produce noxious gases that are harmful to both humans and the laser cutter itself. These unintended externalities are minimized in FabLabs by clear signage and increased control over the laser cutter's use by the fab manager. Regardless of the material used, laser cutters require proper ventilation as most of the models found in FabLabs use a steady flow of carbon dioxide to produce the laser beam and thus produce toxic fumes.

Thought in terms of inputs and outputs, a laser cutter takes energy, digital data, carbon dioxide, and whatever material is being cut, and turns them into engravings, cut out shapes, fumes, and trash. The final output – trash – is a big differentiator between laser cutters and 3D printers, and additive versus subtractive manufacturing more generally. In this context, trash has a rather specific meaning. It does not only refer to that which is unwanted or disposed, but rather that which cannot be used for future work. Something is trash when it has lost its capacity to be transformed in a way that is beneficial to the making of something new in the lab. In principle, 3D printers minimize trash by building something up layer by layer, it only uses the matter it needs to produce an object, whereas a laser cutter extracts, or subtracts, the matter needed in a certain pattern or shape from a larger block of material. What remains is not necessarily trash, but it is more likely to be treated as such.

The laser cutter tends to be the bulkiest and most expensive machine in a FabLab. They cost anywhere between 1,000 and 65,000 euros. There are open-source laser cutters but, unlike 3D printing, the market is dominated by proprietary models. Although the high cost of a laser cutter can be discouraging for new FabLabs or those aspiring to open their own lab, the laser cutter is indispensable to the FabLab model for a number of reasons. Ironically, the fact that laser cutters are still prohibitively expensive for most individual makers creates the incentive to band together to own one collectively. And because they are bulky machines that have specific ventilation requirements, even those makers who might have the financial resources to purchase their own cutter might not have the proper space at home to use it safely, not to mention the electrical costs that can be quite high with extensive use. These apparent inconveniences push people who want to work or experiment with a laser cutter to get involved in a FabLab or makerspace. With 3D printers becoming increasingly affordable and compact, more people could start to do their 3D printing at home instead of in a lab, but the laser cutter would offset that trend.

The other reason that laser cutters are essential to FabLabs, beyond the fact that they are a part of the core shared capabilities that all labs should have, is that, like 3D printers, they are seductively futuristic. Despite the fact that laser technology is not new – CDs and DVDs, for example, are both read by a laser – the laser cutter allows you to see the laser at work. One can observe in real time the laser as it slices and engraves a design with remarkable precision. The spectacle of the laser cutter at work, especially when paired with the activity of a nearby 3D printer, elicits feelings of stepping into a future of endless possibility and technologies once reserved for science fiction. People are drawn to this novelty and FabLabs exploit this fact to bring more people through their doors.

iii. CNC Mills

For jobs that 3D printers and laser cutters cannot manage, there are computer numerically controlled (CNC) mills. Like a laser cutter, a mill consists of a tool head suspended over a work bench where materials are placed to be cut or drilled. Controlled by a computer, the head can move across multiple axes – three to five axes, depending on the sophistication and cost of the machine. Different bits can be inserted in the mills head to perform different functions. Although CNC mills are generally less precise than laser cutters, their main advantage is that they can cut through metal. Moreover, large CNC mills can work over a greater surface area, making them better equipped for jobs that involve larger pieces of wood, such as when making furniture.

The process for making something with a CNC mill mirrors that of laser cutter. First, one has to create a digital model in a CAD software application, such as Inkscape or AutoCad. Next, that file has to be converted into the instructions (written in G-code) that the CNC mill's computer can process and act on. The conversion from CAD file to G-code is done by a computer-assisted manufacturing (CAM) software application, most of which are proprietary. It is generally recommended that people learn how to program in G-code to be able to identify and correct mistakes in the conversion. Finally, the G-code instructions are sent to the machine and processed into sequential movements by its internal computer and motor.

CNC milling machines have been around since 1952, but their use in industrial production only took off in the 1970s and 80s. Today, CNC milling machines are commonplace in the manufacturing of metal parts for cars, planes, and trains, home appliances, and in the production of wooden and metal furniture. This means that industrial grade CNC milling machines can cost millions of euros. Fortunately for

FabLabs, more modest mills can cost as little as 200 euros. There are also many open source designs that allow people to assemble their own mills with low cost electronics and parts that can be sourced cheaply or even made in a FabLab. The Mantis mill is particularly popular, as the project leaders have affiliations with the CBA at the MIT and the FabLab community. Like the RepRap, the Mantis project gives labs of modest means the possibility to increase their productive capacities. More importantly, it offers a lab's members the opportunity to contribute to its evolution, to feel invested in the lab and the community by virtue of a tangible and lasting effect.

Having gone through the essential components of a FabLab, I turn now to the ways in which FabLabs practice invention. I argue that they are developing an alternative politics of invention that creates a virtuous cycle between technological invention and learning. While this politics is de-proletarianizing, I note that there are major limiting factors which currently curtail the FabLab's de-proletarianizing effect.

IV. Invention in the Lab

FabLabs promote a virtuous politics of invention. The underlying principle of this politics is to "do what you want, but try to contribute something to life in the lab" (Interview 6). While every lab practices this principle differently, there is a commonly held conviction that a FabLab is more than a shared workspace or a tool library; it is a site of individual and collective development. Every technological invention should be made available to the rest of the lab and the FabLab network at large so that others might learn from it or give feedback. Every technique, tip or insight should also be shared, either in the form of a live workshop in the lab, or in the form of a video tutorial posted online (or both). One person's technological invention should be the seed of another's learning, and vice versa.

i. Distributed Networks

The organizational model that FabLabs seek to emulate is that of the *distributed network*. In computer science, a distributed, or peer-to-peer (P2P), network, is distinguished by its lack of a fixed client-server structure. Normally when we use the Internet, our web browsers act as clients in networks that are centred around servers. When we type in a webpage's URL or click on a link, our browser sends a data request to the server that stores, or hosts, that page and its data. The server then processes that request and either sends the data to the client or doesn't. The client-server model is used with differing layers of complexity, but its logic is one of centralization, with clusters of clients forming around servers that control the flow of data across the network.

In a distributed network, each node, or peer, is able to both request a data transaction (client) as well as provide requested data (server). Peers will differ in processing speed, storage capacities, and network bandwidth, but that doesn't matter so long as they all oscillate between client and server functions. In other words, a distributed network does not require that its nodes be identical, only that they are able to have reciprocal interactions.

P2P file-sharing networks most clearly illustrate this dynamic. In a client-server network, a client receives a file from a single server. In a P2P network such as BitTorrent, however, the download process is more complex. The user must first download a torrent-file off the web, using the standard client/server model. Once a torrent-file is downloaded, the device is connected to a network of other computers, or 'seeders,' that are storing the desired file to download, as would a server. Rather than a continuous stream of data from a single source, however, the user receives data from several seeders until the whole file has been downloaded, with the torrent file piecing the whole puzzle together. Crucially, as soon as the user's client program starts receiving data from seeders, it concurrently uploads (seeds) the newly acquired data to other computers downloading (leeching) on the network. Any peer on the network is therefore performing both client and server functions simultaneously.

The traditional client-server model finds its logic in a clear division of labour and economies of scale. Large servers can process and provide data to multiple clients at a time, quickly, and reliably. Yet problems arise when the number of clients exceeds the server's processing power: the server either slows down significantly, begins to reject requests, or crashes from the overload. Saturation points are intrinsic to the model and, at any given moment, performance is optimal at a particular client-server ratio. The P2P model, on the other hand, is underpinned by a radically democratic logic. Its productivity and performance increase exponentially with the number of peers on the network. More peers means more seeders, more sources of data, and faster downloads.

The logic of P2P is present both within and between FabLabs. Within a lab, the aim is to have a horizontal organizational structure where each member oscillates between client and server, giver and taker, student and teacher. One can give in a variety of ways: by sharing their knowledge and know-how on specific machines or software applications; by assisting others in their projects; or by documenting the work they did on a particular project and sharing it with others in the lab or online. Those who feel confident enough in their abilities are encouraged to run workshops on their area of competency. The working assumption is that, no matter how new you may be to the lab, or digital fabrication more generally, there is always something that you can contribute, even if it is something like a language skill or cooking food for other members.

The same principle applies to the FabLab network and the interactions between labs. What sets FabLabs apart from other shared machine shops is their commitment to a shared 'inventory of core capabilities' (CBA 2012). An object designed in Boston should be replicable in Barcelona because the productive capacities in both labs are roughly equivalent. Thus, a 'shared technological typology is necessary so that each FabLab might reproduce projects developed in the network' (Menichinelli 2015: 33). It is for this reason that a FabLab must have a least one 3D printer, a laser-cutter, and some kind of computer numerically controlled (CNC) mill, the basic equipment of digital fabrication. The organizational strategy of the FabLab network is built on the P2P principle that relatively modest capacities shared across multiple sites can be just as powerful, if not more so, than more sophisticated capacities that are highly localized and concentrated.

In practice, FabLabs manage to emulate a distributed network with varying degrees of success. Whereas peers automatically give and take in a P2P file-sharing network, FabLabs must rely on the willingness of their users to make contributions to the network, all of which require additional work and effort. The simplest way a member can contribute is by uploading a CAD file they made to one of many online repositories. The next step up is to document a project step-by-step with pictures and instructions, akin to a recipe. Unsurprisingly, the lack of documentation is a persistent issue for most labs. Wolf et al. (2014) note that, while most users agree on the importance of documentation, they also find it tedious, time consuming and difficult. One of my research participants likened it to scripting a sexual encounter (Interview 20).

Projects will also go undocumented or kept secret because members are shy about sharing their work or they intend to license it in the future. Regardless of the reason, there is a unanimous consensus among my research participants that documentation should be more consistent, and that "there are more takers than makers" (Interview 18).

Nevertheless, the distributed model still functions, especially in a FabLab. Outside of structured workshops, where one still finds traditional teacher-student dynamics, the learning that takes place within a lab stems primarily from micro-interactions between members asking each other for assistance or advice on this or that task. Unless you are dealing with a student on a deadline, or someone with diminished social skills, such requests for help are usually well-received because most members understand that they are there for each other as resources and collaborators. Frequently, members simply imitate others they perceive to be competent.

From my interviews with FabLab users, the most cited benefit of making in a lab is the opportunity to interact with people of various skill sets (Interviews 2; 9;10; 14; 15; 18). Once again, it must be stressed that the skill sets in question all relate to making in some sense, be it digital design, coding, carpentry, metal work, electrical engineering, or embroidery, skills that are drawn from a minority of the general population, mainly from creative professionals and students. Still, the sense among users is that nobody enters the lab an expert in making or, put differently, nobody is in a position to take full advantage of all the possibilities afforded by a FabLab's capacities. They describe the feeling of entering the lab as equals in their limitations and excited at the prospect of acquiring skills that they were not taught in university, college, or at work.

ii. The Internet and the Power of the Digital

The real strength of the FabLabs' politics of invention lies with their use of the Internet and digital information. The ability to access online repositories with thousands, if not millions, of documented accounts of other people's experiments and designs, all for the relatively affordable price of an internet connection,[8] amplifies the learning potential of all FabLab members. And because all digital fabrication starts with a digital file, the FabLabs benefit from digital technology's ability to minimize the loss of information between repetitions.

Whereas analog devices capture, store, and transmit waves of information that are continuous, digital machines capture, store, and transmit information as whole numbers, typically the digits 1 and 0. The ongoing digital revolution in communication consists primarily of transforming analog information into digital information and then back into analog information so that it is intelligible to humans.

With digital fabrication, analog information – the continuous lines of the computer model – are immediately captured as digital information so as to eventually reassume its analog state in a physical object. In both cases, 'transformation' may be something of a misnomer. Analog signals are not literally transformed into digital symbols, nor are digital symbols literally transformed into physical objects. It is more accurate to say that machines translate one flow of information into another, analog to digital, and vice versa. Like in linguistic translation, the goal is to preserve as much of the original information as possible when moving from one representational system to another. These processes are inevitably imperfect, but digital technology has found favour in most applications because it exponentially reduces the amount of errors that occur in those translations.

Prior to the Internet, information circulated via written material as books, newspapers, magazines, and letters, as audiovisual content on television and radio, between people in formal educational settings, such as schools and universities, or informal settings, between friends and neighbours, and, finally, between people and the objects that they were interacting with. The Internet did not render these transmission mechanisms obsolete, but rather added a new mechanism to the fold.

8 One should not forget, however, that Internet access is poorly distributed across the globe, with nearly 60 percent of the world's population still without access to the Internet (World Bank 2016).

This new mechanism dramatically reduced the geographic and practical barriers to receive and transmit information. Instead of going to a library or a bookstore, the Internet made it possible to access a wealth of information on a computer wherever an Internet connection was to be had.

Just as accessing content became easier, so too did publishing content. Especially remarkable was the willingness of so many people to provide their content free of charge. All of this is taken for granted now for that 40 percent of humanity with Internet access, but there was no reason why the Internet couldn't have been more commercial from the onset. The launch of the World Wide Web in 1993 meant that information was less restricted by spatial proximity than by linguistic barriers, the spread of the underlying physical technological infrastructure that the web depends on, as well as government restrictions placed on web access.

Still, the shortening of spatial and temporal distances in the dissemination of information was less revolutionary than the Internet's change to the power relations between emitters and receivers of information. Television and radio are mainly one-way transmitters of information: those who own the means of communication decide what content is transmitted and when. Consumers of these media have very little control over the flow of information, beyond being able to choose which programs to listen to. If you wanted to create a consumption schedule that differed to that set by radio stations and television broadcasters, you would have to record a program on a video or audio cassette. Viewers and listeners had to create their own archives of past transmissions or seek out recordings from other sources. The mnemonic potential of these technologies – their capacities to record and store information – was constrained by the limitations of the magnetic tape used for both video and audio analog recording.

The Internet not only dramatically expanded mnemonic capacities, it also gave power to the receiver to decide when information should be transmitted. The receiver could now choose when to instigate the transmission of information from servers, machines that act as archives of digital information that can be connected to networks such as the web. Although servers reserve the right to discriminate between requests for data from clients, granting certain requests while denying others, they do not initiate transmissions. This freedom to choose when information is sent and received has gradually broken the audiovisual broadcast industry's control on the time of information transmission.

Remarkably, the Internet is actually closer to the printed word than television and radio when it comes to the balance between transmitter and receiver. With books, newspapers, and magazines, information is transmitted in a physical form that can be accessed at the reader's leisure, with total control over when to stop reading, when to resume, and how many times a text is re-read. That same control is afforded to the Internet user, with the major difference that most of the information available online is non-rivalrous. Economists call a good non-rivalrous when it can be consumed without preventing others from consuming it as well. A book, for example, is rivalrous because it is generally only read by one person at a time. A webpage, however, can be transmitted to as many browsers as is possible for the server that hosts the page to handle. Hence, the power of the Internet to maximize the dissemination of content beyond the capacities of physical text.

Networked digital content, the desire to share information online for free – even if driven by an ulterior profit motive – and the relatively affordable cost of computers and web access, have collectively created an alternative resource for learning outside of the institutional settings of schools, colleges, universities and workplaces. FabLabs and other makerspaces take full advantage of this resource and the iterative power of digital information to stimulate learning and technological invention. The challenge, however, is to get members to produce and share digital information, be it in the form of CAD files, project documentation, or online tutorials.

What is more, the availability of free and open source CAD software, such as Inkscape and Blender, not to mention unlawfully distributed proprietary software, means that the financial barriers to entry are low for the world of digital design, at least in the Global North. One only needs a computer and an Internet connection. FabLabs and makerspaces complete the picture by providing affordable access to digital fabrication hardware and the possibility to learn with other people.

Making things in public even separates FabLab users from many makers who do not frequent shared machine workshops, but do their making at home. Many interviewees explained that they would go to the FabLab to do things that they could just have easily done at home, some even bringing their home equipment to the lab and leaving it there for communal use (Interviews 4; 5; 13; 14; 15; 18). Several reasons are given for this behaviour, such as wanting to share with others or enjoying the sense of community and comradery at the lab. For one member at le Petit FabLab de Paris, moving his soldering station to the lab meant that he would have to open the lab for all to use if he wanted to do any work, thereby creating a positive externality from his desire to make (Interview 8).

Simply put, the barrier to entry for those looking to become a 'maker' or 'Fabber,' as FabLab users are sometimes referred to (cf. Grosskopf 2013), is not restricted access to quality educational content. For those who live in proximity to a FabLab or makerspace, they are no longer constrained by limited or highly controlled access to expensive digital fabrication machinery.

All of this suggests that FabLabs have a significant de-proletarianizing potential. Not only do they promote a virtuous politics of invention, they give their members the freedom to formulate their own problems in the lab, and to avail themselves of the plethora of digital information online related to digital fabrication. And still, the cumulative effect that FabLabs have had on the collective problems of the day has been negligible. In the following section, I discuss some of the reasons why FabLabs have failed thus far to have a palpable de-proletarianizing effect on the societies in which they operate.

V. Proletarianization against FabLabs

Although FabLabs and the maker movement have a significant de-proletarianizing potential, there is little evidence that this potential is having much of an impact outside of a narrow section of the general population. In her ethnography of FabLab Amsterdam, Maldini (2014: 1107) notes that 'most of [the lab's] users are students and professionals in architecture, art and design using digital tools to explore or develop creative projects.' My own ethnographic research supports this finding as well. The dominance of these two groups in most labs has important repercussions for the question of whether FabLabs are sites of de-proletarianization.

Above all, it shows that FabLabs have yet to penetrate mainstream society beyond those individuals that already possess a relatively high degree of technological literacy thanks to their professional and educational backgrounds. For all their intentions of democratizing access to digital fabrication tools, FabLabs currently carry little appeal to people who have limited technological competences. Instead, FabLabs offer relatively skilled users the opportunity to develop their digital fabrication abilities and experiment with machines that they could not access otherwise.

There is indeed a democratization of access to digital fabrication tools, but the portion of the population that is availing itself of that access is very small and, for the most part, already engaged in the production and design of technology. There is also a clear underrepresentation of women among FabLab members (Bean, Farmer & Kerr 2015). The relative homogeneous makeup of FabLabs is a major limiting factor on their de-proletarianizing potential because it means that they are not taking a variety of perspectives into account when formulating problems and responses.

There are many quick and seemingly obvious answers to explain the minimal impact that FabLabs have had on the current social, political and economic landscapes in European societies. The simplest is that the majority of people in those societies are caught in a socio-economic constellation that rests on the division of labour, private property and restricted access to the resources that prolong and enhance human life. The first pillar – the division of labour – has proven to be a very effective way to produce a great many resources and the currencies needed to access them, while the second and third pillars are regarded as necessary to manage the scarcity of resources, by which I include goods and services in addition to natural resources. Because of this arrangement, most people have neither the time nor the interest to invest in developing skills that are not monetizable. Given that to use a FabLab requires skills that are rare among the general population and not readily monetizable, it makes sense that FabLabs only appeal to those for whom better digital fabrication skills serve an ulterior professional or educational purpose.

While it is true that contemporary capitalism has a tendency to limit the leisure time of most wage and salaried workers, a purely economic analysis of why people do not get involved with their local FabLab is deeply flawed. Not only do we humans invest a great deal of time and energy into activities that do not reward us financially, we also operate within social and material contexts that inform our decisions.

i. Proletarianizing Thoughts

I maintain that one of the primary obstacles to greater participation in the maker movement is a pervasive sense of technological incompetence. Digital fabrication requires a reasonable proficiency in a number of software applications, especially a CAD design program. It is with CAD software that users are able to create the digital models of the objects that are then materialized by machines such as 3D printers and laser cutters. Thus, 'in order to create [physical] artefacts, one has to know how to create digital models' (Katterfeldt 2013: 143). Without a rudimentary understanding of a CAD application, it is difficult to make the most of what a FabLab has to offer. Learning how to render workable digital models takes a great deal of time, effort, and patience to reach a base level of competence. This varies from program to program, some having much steeper learning curves than others, but all require an initial investment that is substantial enough to discourage the uninitiated, people outside of the maker movement who assume that they lack the technological know-how to even learn, let alone make.

The feeling of incompetence in the face of new technologies is a powerful proletarianizing force. I know this because I have felt it throughout this research project. As someone who considers himself to have an average level of technological competency – meaning that I know how to use a computer to access the Internet, write word documents, store music, photos and videos, but I don't have any formal or informal training in computer science and programming – I have seen people in FabLabs do things that strike me as beyond my capacities, not only my current capacities, but those that I could ever aspire to. Thoughts cross my mind such as, "if only I had taken a programming course during undergrad or high school," or "I am a qualitative social scientist, I don't need to know this stuff," or quite simply "I have a thesis to write, no time to mess about with learning something from scratch." These defensive and rationalizing thoughts are fundamental expressions of a proletarianized mind.

These proletarianizing thoughts do not stem from a hegemonic public discourse that discourages learning new skills. As mentioned earlier, the discourse around high-tech workers and the need to skill or re-skill workers in all things digital is dominant in all mainstream discussions of work and education. Instead, the main factors that account for this attitude are the pervasive application and belief in the division of labour and the need to specialize, real and perceived time constraints, the ignorance of alternative educational pathways, not to mention lethargy and a lack of desire to learn. While the first two factors can be attributed to a capitalist system that threatens us with destitution, diminished quality of life and social standing, lest we fail to offer goods or services that others are willing to pay for, the remaining factors are more directly related to the phenomenon of proletarianization.

That people are ignorant of alternative educational pathways means that there is still a widespread difficulty to consider and accept as legitimate the learning that occurs outside of an institution such as a school, university, college or workplace. What goes underappreciated is the sheer amount of instructional content available online, much of which is free to access. I discovered as much myself recently when, after years of putting it off, I finally decided to learn how to make and record music on a digital audio workstation (DAW), i.e., software that allows you to create your own music with real and midi instruments. As with digital modelling, I kept telling myself that I lacked the technical ability to do anything worthwhile with a DAW. Having played musical instruments since my childhood, I even came to resent the fact that people could produce music while I could not, despite the fact that they lacked my formal musical training.

When I stopped finding excuses and made the leap to start learning how to use a specific DAW, my first surprise was how much quality educational content I could find for free through blogs and YouTube videos alone. The second surprise was how quickly I went from not knowing where to start, to making bearable sounds, not full songs, but something with a bass line, drum beat, melody and accompaniment. Since I was using a midi keyboard, my years of playing the piano served me well, as did my basic understanding of music theory and composition, but beyond that, making music on a computer was a completely different experience than playing with live instruments and other musicians.

I have taken this autobiographical digression to highlight two things: first, that it is possible to learn how to use new software outside of a formal educational setting, and, second, that doing things digitally is completely different to doing them non-digitally. Neither are particularly revolutionary insights, but both bare remembering when thinking about proletarianization. The first point is testament to the fact that the Internet has dramatically expanded access to information that can help people learn new skills, new ways of interacting with software and hardware. The second point suggests that, contrary to Stiegler's claim, know-how is not lost when it becomes possible to do something with the assistance of digital technology.

ii. Digital Fabrication and Proletarianization à la Stiegler

If we were to make sense of Stiegler's claim that know-how is lost in its technological exteriorization, we could argue that digital fabrication poses a threat to traditional trades, such as carpentry, metalwork, sculpture, and engraving, just as the skills required to play non-digital musical instruments might be threatened by the spread of digital music production. The problem with these claims is that it assumes a transfer rather than a translation of know-how.

Following DeLanda (2016: 161), I understand know-how to be 'knowledge taught by example and learned by doing.' This definition applies to both digital fabrication and the traditional trades. The difference is that traditional trades tend to require a greater somatic involvement, i.e., a training of the body and its muscles to act with instruments, to create muscular adaptations and muscle memory, as well as to develop the necessary hand-eye coordination. Digital fabrication, meanwhile, recruits different psychic and somatic capacities, even if it adds to the chain of mediating beings between the human actor and the finished products. The end result is a new set of practices that enlists human and nonhuman capacities differently, not a zero-sum transfer of know-how from body to machine.

The simple fact is that numerically controlled machines do what tool bearing humans cannot. The most skilled craftsman or engineer will never match the precision of CNC tools, nor the machine's capacity to make identical iterations of the same model. If, indeed, digital fabrication is undermining the preservation of traditional trades, this would have little bearing on the problem of proletarianization as I understand it. The romanticization of traditional crafts, which Alex Williams and Nick Srnicek (2015) note is increasingly common in certain leftist circles, loses sight of the urgent political need to appraise the current state of our technological capabilities so that we might better formulate and respond to pressing social, political and economic problems.

Conclusion

I started this chapter by introducing the notion of a politics of invention, defined as the dynamics between technological invention and learning. Both forms of invention are problematic in the dual sense of responding to problems and forming new problems. In the case of technological invention, the object is a problem of composition between parts with various capacities, and a problem of integration with other beings in its environment. In the case of learning, the human is able to include herself as a condition of the problem and activate new capacities by crossing certain intensive thresholds.

FabLabs offer a virtuous politics of invention by interlinking technological invention and learning. They make use of the power of digital information, its iterability and mobility, to dissemination inventions across the Internet, while also fostering a live distributed network between peers within each lab. When combined, these strategies allow people to interact with technology in ways that transcend the consumerist relation to technological objects.

Unfortunately, the de-proletarianizing potential that FabLabs have is poorly distributed across the general population, favouring those who already have a certain degree of technological competency. In the following chapter, I continue my analysis of the FabLabs as sites of de-proletarianization, this time through the conceptual lens of resistance.

5. FabLabs and Resistance

Introduction

Unlike invention, resistance is a concept that has received a great deal of attention from sociologists and criminologists, as well as philosophers, and political theorists. As a consequence, its meaning is contested. Nevertheless, resistance is regularly theorized as that which opposes power in all its guises, whether it be an established political institution or states-person, a reigning economic system, a wealthy corporation or individual, an authority figure, or a social structure. The common narrative is that resistance says no to power; it is the subordinate's act of defiance or non-compliance with the directives of power. In their extensive review of the sociological literature that employs the concept, Jocelyn Hollander and Rachel Einwohner (2004) note that resistance almost always involves some form of opposition, typically to some force external to the resisting actor. Strikes, protests, and even certain acts of violence are all generally understood as acts of resistance, particularly when they are committed by groups or individuals that are considered disadvantaged, marginalized, or oppressed.

In certain criminological circles, there is a growing concern that the term resistance has been abused to the point that all behaviour that falls outside of the mainstream is considered resistance. Such voices would object, for example, if I were to claim that FabLabs and their users are engaged in a form of resistance simply because they are doing something unusual in the eyes of society. However, that is not my intention. Nor is it my intention to follow Hayward and Schuilenburg (2014) in redefining resistance as creation, or invention. The very title of this thesis suggests that I regard invention and resistance as distinct concepts and practices. Instead, in this chapter I set out to define resistance within the confines of my capacities-based ontological framework and determine the role that such a resistance plays in the dynamics between the FabLab network and the process of proletarianization.

Like I did with invention in the previous chapter, I start with a theoretical appraisal of resistance as a concept, specifically as theorized by Michel Foucault. Via Deleuze, I tie Foucault's analytics of power to Spinoza's theory of affect, in order to develop a distinct definition of resistance as that which limits and restricts intensive interactions. In section II, I look at the ways in which resistance, as I define it, relates to the process of proletarianization. By decoupling it from the superior-subordinate relationship, I argue that we come to see resistance as a strategy that can be used for both conservative and transformative political purposes. Indeed, it is Power's effective use of resistance that must be recognized, particularly the resistance that is embedded in consumer products. Finally, section III investigates the role that FabLabs can play to reverse the trend of proletarianization. I conclude that, while they are essential to addressing technological illiteracy, they currently fail to properly problematize themselves politically.

I. Resistance in Theory

Resistance is typically thought of in political terms as resistance to the status quo, to the powers that be. To resist is to oppose hegemonic forces and fight for change. In this section, I suggest a different understanding of resistance, one that is more ontological than political. Keeping with my own ontological commitments, I believe it necessary to develop a concept of resistance that is not exclusive to human beings and our institutions, one that includes the nonhuman as well. This would imply breaking with the idea that resistance is something a human subject chooses to do. Later, we will see how these more broadly accepted acts of resistance fit within a wider ecology of resistance. Indeed, to think of resistance as distributed across a heterogeneous ecology of beings is essential to this endeavour, which is why I start by considering Foucault's theory of distributed power and resistance.

i. Foucault and Resistance

Considering how frequently he features in academic debates on the subject, Foucault wrote relatively little about resistance. It is less surprising, however, if we consider how closely intertwined power and resistance are in his work. By power, Foucault does not mean the traditional definition of political power that belongs to a central authority figure or institution. Instead, he understands power to be an ontological field of forces, dynamic relations between forces that circulate through everything. Power, in the Foucauldian sense of the term, is *productive.* It is both morphogenic and ubiquitous, giving shape to things, more than it is repressive, as is commonly thought in political theory.

In *History of Sexuality Volume I:,* Foucault (1978) outlines what he calls an analytics of power, rather than a theory of power. While the notion of an analytics has many different meanings in philosophy, Immanuel Kant's distinction between 'analytic' and 'synthetic' judgments is helpful to understand what Foucault had in mind. In his *Critique of Pure Reason*, Kant (1998: 130) writes:

> In all judgments in which the relation of a subject to the predicate is thought...this relation is possible in two different ways. Either the predicate *B* belongs to the subject *A* as something that is (covertly) contained in this concept *A*: or *B* lies entirely outside the concept *A*, though to be sure it stands in connection with it. In the first case I call the judgment analytic, in the second synthetic.

Analytic judgments reveal predicates that are contained, hidden even, in the subject under investigation. A Kantian analytic decomposes subjects into the manifold contained within them. Conversely, synthetic judgments are compositional in that terms external to one another are combined, much in the way we add three to seven to make ten.

When Foucault proposes an analytics of power, he retains the decompositional aspect of the Kantian analytic while rejecting the logic of subjects and predicates. Power operates below the surface; we do not immediately *see* power. This is because power, according to Foucault (1978: 82), belongs to a 'specific domain,' an abstract and 'informal dimension' (Deleuze 1988b: 34): that of forces. In a crucial passage of *History of Sexuality Vol. I* Foucault (1978: 92-93) writes:

> power must be understood in the first instance as the multiplicity of force relations immanent in the sphere in which they operate and which constitute their own organization; as the process which, through ceaseless struggles and confrontations, transforms, strengthens, or reverses them; as the support which these force relations find in one another, thus forming a chain or a system, or on the contrary, the disjunctions and contradictions which isolate them from one another.

We learn from this passage that power refers to a localized distribution of relations between forces. More accurately, power is 'a relation between forces, or rather every relation between forces is a 'power relation'' (Deleuze 1988b: 70). None of this is intelligible, however, without a better understanding of the term *force*.

In *Nietzsche and Philosophy* – a book that Foucault (in Deleuze 2004: 211) acknowledges influenced him greatly – Deleuze states that force is not matter, but that matter is the formal expression of relations between forces of 'different quantities, qualities, and directions' (Deleuze 1983: 50). Forces are unequal, and it is 'by virtue of their inequality' (Foucault 1978: 93) that they are productive. What then do forces produce? They produce relations that are themselves new emergent forces. A force is 'already a relation' (Deleuze 1988b: 70) between other forces, which is to say, it is a power relation. Thus, power is everywhere, 'not because it has the privilege of consolidating everything under its invincible unity, but because it is produced from one moment to the next, at every point, or rather in every relation from one point to another' (Foucault 1978: 93).

That forces form relations tells us little about how and why they do so. From Foucault's extended quote above, we can surmise that forces act antagonistically, battling against each other in 'ceaseless struggles and confrontations' that can have the effect of transforming, strengthening, or reversing existing power relations. Still, this only adds to the list of unanswered questions: why do forces relate, and why do they struggle against each other? Put differently, why don't forces just leave one another alone?

A first possible theory would start with an idea best expressed by Spinoza (1996: 75), namely, that 'each thing, as far as it can by its own power, strives to persevere in its being.' This striving for perseverance, or self-preservation, is called the *conatus*. If every force was guided by a *conatus*, then perhaps forces enter into relations in the interest of self-preservation. The assumption would be that forces would fair better within certain relations than on their own. All of this presupposes that forces are in a position of vulnerability to begin with. If forces were permanent, or if forces could not affect each other, then there would be no striving, no effort to persevere, but simply being. To apply Spinoza's theory of the *conatus* to Foucauldian forces, we must assume that a force can cease to exist. Hence, the next step would be to understand how a force is destroyed.

Having already established that a force is a relation between other forces, it stands to reason that a force ceases to exist when its terms are no longer related. A force is vulnerable, therefore, in so far as it risks not having the terms necessary to maintain its relation. If, to use a simplified example, force *a* is constituted by the relation between forces *b* and *c*, then *a* depends on *b* and *c* remaining in relation to each other. Were a force *d* to come along and form a new relation with *b* or *c* that severed the *b*-*c* relation, our initial force *a* would cease to exist. A less abstract example of this occurrence would be a romantic infidelity, in which case *a* would be the relationship between exclusive partners *b* and *c,* and *d* would be the intruding lover.

Whether a romantic relationship is guided by a *conatus* is debatable, but this example serves to highlight the fact that a force is vulnerable because the forces that compose it retain capacities that can be expressed in ways that undermine its integrity. In fact, to the question of *how* forces relate, we should respond that it is by nature of their capacities to affect and to be affected by one another. A power relation occurs when a force's capacity to affect connects with another force's capacity to be affected. Although Foucault himself did not explicitly embrace the Spinozist notions of capacities to affect and to be affected, Deleuze (1988b: 71) argues that this is implied in the former's thought, and that 'force defines itself by its very power to affect other forces (to which it is related) and to be affected by other forces.'

Just as a whole does not totally dominate its parts, a relation does not completely control its terms; the best it can do is exert a pressure on its terms to stay related. In the case of the romantic relationship *a*, the terms, partners *b* and *c*, still have capacities to affect and to be affected that can form new relations or break old ones such that the relationship ends. As a consequence, relationship *a* would benefit from relations with other forces that reinforced the bond between *b* and *c*: food, laughter, conversation, or sex, to name a few. The *conatus,* coupled with the recognition that a force is dependent on the continued expression of its constitutive relation by terms that are beyond its control, would push it to form relations that strengthen the connection between its terms.

However, the example of the romantic relationship raises another question: do forces enter into relations on their own accord or by some other mechanism? Typically, when a power relation is invoked in political or social theory, it implies a power imbalance between a dominant force and a dominated force. The dominant force imposes the relation on the dominated force, rather than both forces entering into a mutual accord as one would hope is the case in a romantic partnership.

The introduction of this qualitative difference between forces – dominant and dominated – would help explain the litigious nature of forces that Foucault suggests. Dominated forces would struggle against dominating forces, while the latter struggle to maintain their dominant positions. In this case, resistance could be the efforts made by the dominated forces to limit or overcome the power that the dominant forces have over them. In another important passage from *History of Sexuality Vol. I*, Foucault (1978: 95) writes:

> Where there is power, there is resistance, and yet, or rather consequently, this resistance is never in a position of exteriority in relation to power... [The existence of power relations] depends on a multiplicity of points of resistance: these play the role of adversary, target, support, or handle in power relations...They are the odd term in relations of power; they are inscribed in the latter as an irreducible opposite.

Despite the ample room for alternative readings that this quote provides, it is clear that Foucault understands resistance as something internal to power relations. Resistance occurs within a relation between forces, as the odd term in the relation. Pictured formulaically, we could state a Foucauldian power relation as:

$$\text{Power Relation} = (\text{Force } a^{\,Power} \rightarrow\leftarrow \text{Force } b^{\,Resistance})$$

However, the problem with this schematic is that it contradicts our earlier claim that forces *a* and *b* can only relate if they have corresponding capacities to affect and to be affected. If both forces need to express capacities in order to relate, then power does not reside exclusively on one side of the relation. Thus far, I have followed Deleuze in describing a power relation as follows:

$$\text{Power Relation} = (\text{Capacity to Affect}^{Force\ a} — \text{Capacity to be Affected}^{Force\ b})$$

If we wish to follow Foucault in situating resistance within a power relation, where then do we place resistance in this equation? According to Françoise Proust (2000: 18), '[w]e are indebted to Michel Foucault for having generalized, while also displacing, the physical law of resistance: every force, while it is affected by another force, provokes a resistance which thwarts the action of the first force, while falling short of stopping it.' With this in mind, we could amend the equation like so:

$$\text{Power Relation} = ((\text{Capacity to Affect}^{Force\ a} — \text{Capacity to be Affected}^{Force\ b}) \leftarrow \text{Resistance}^{Force\ b})$$

In this formulation, resistance is exclusive to force *b* as that which reacts to the relation between its capacity to be affected and force *a*'s capacity to affect. By merging Foucault with Deleuze's Spinozist understanding of power, we end up with a theory of power relations that takes three factors into consideration – capacities to affect, capacities to be affected, and resistances – instead of two. Power becomes the interplay of these three variables at different values. We could start to imagine different kinds of power relations that vary according to how much resistance a relation elicits. A romantic relationship, to go back to our example, would be characterized by less resistance than, say, a street brawl.

Before getting carried away by a typology of power relations, I must circle back to the question of why forces relate. Qualifying forces as 'dominant' or 'dominated' implies that it is advantageous to be a dominant force and disadvantageous to be dominated. What does a dominant force gain from its domination of another force? We have already considered one possibility, namely, that a force gains an ally in its efforts to persevere in its being, but that does not quite answer the question. When a capacity to affect encounters a suitable capacity to be affected, they co-produce an effect which is a power relation and a new force with its own capacities to affect and to be affected. It is this new force's capacities to affect that determine whether it is a beneficial or detrimental relation for the constituting forces, both the dominant and dominated. If the new force affects the dominant force positively, only then can we say that the dominant force gains something from the relation. Let us consider this scenario schematically in two steps:

i. (Capacity to Affect$^{Force\ a}$ —— Capacity to be Affected$^{Force\ b}$) ← Resistance$^{Force\ b}$ = Force *c*

ii. (Capacity to Affect$^{Force\ c}$ —— Capacity to be Affected$^{Force\ a}$) ← Resistance$^{Force\ a}$ = Force *d*

The first step simply illustrates that the relation between force *a*'s capacity to affect and force *b*'s capacity to be affected, and its resistance, produces an emergent force *c.* In the second step, I show that force *c*'s capacity to affect forms a new relation with force *a*'s capacity to be affected, plus resistance, to create a new force *d.* If this is starting to look like an infinite regress, we should remember that there is no guarantee that step one will lead to step two. Force *c* can only affect force *a* if they have corresponding capacities to affect and to be affected. It is very possible that *a* could be entirely indifferent to *c*, by which I mean that the former cannot be affected by the latter. Still, it is crucial to note the viral nature of forces; that new forces with new capacities are produced in all relations between forces.

We also discern from this example that force *a*, while dominant in relation to force *b*, is actually dominated by force *c,* i.e. the effect of its relation to *b*. That being said, we can start to understand why force *a* would want to maintain its dominant position over force *b*, namely, because of the effect that force *c* has on *a.* Yet again, however, we are brought back the question of why a force would want to relate to another, in this case, why force *a* would want to relate to force *c*, especially if it would do so as the dominated force in the relation.

Thus far, I have focused on the fact that forces relate thanks to their capacities to affect and to be affected and, in so doing, create new forces with new capacities. I have also suggested, following my Deleuzian interpretation of Foucault, that relations between forces provoke resistance on the side of the affected, or dominated, force. We have yet to interrogate why affected forces resist, and why they do so to varying degrees. The instinctive response would be that a force resists because, to put it plainly, being dominated is bad. The problem with this solution, however, is that it appears to exclude the possibility that the effects of being affected can be good. In part, this has to do with the qualifiers dominant and dominated being loaded with normative implications. As a consequence, I believe it is better to refer to them as affecting and affected forces in a power relation, where the former expresses a capacity to affect and the latter a capacity to be affected. This terminological substitution makes it easier to consider the differences between good and bad affections.

ii. Spinoza's Affects

Making the distinction between good and bad affections brings us back to Spinoza and his unique ethical framework. In his *Ethics*, rather than declare universal moral maxims that all should obey, Spinoza theorizes good and bad in relation to individual beings, human and nonhuman alike. Not to be confused with moral relativism, Spinoza's ethics is grounded in the principle that *good* is to a being that which affirms its existence. By extension, something is *bad* for a being if it denies its existence. Applying the *conatus* that I introduced earlier, we could expand these definitions of good and bad to say that good things allow a being to persevere in its existence and bad things undermine that effort. While Spinoza does in fact agree with these definitions, he moves beyond them to consider different ways of persevering in existence, i.e., different ways of living. For an existing being, the ethical question is not limited to matters of mere survival, but also consists of a striving for the highest obtainable good. To make sense of this claim, we must briefly consider Spinoza's broader ontology.

Spinoza (1996) posits the existence of a single substance that gets expressed in an infinite number of 'attributes' and 'modes.' Each human being, for example, is a mode that exists in the attributes of thought and extension. Nonhuman beings are also modes of the same substance, called Nature or God, but it is uncertain whether they share the attribute of thought. All modes – human or otherwise – have an essence that is singular, eternal, and defined by a degree of power, 'an intensive part of the power of God or nature' (Armstrong 1997: 65).

To each modal essence, to each degree of power, there is a corresponding 'ratio of motion and rest' (Spinoza 1996: 43) that can come into existence, but only when 'an infinity of extensive parts are determined from without to come under the relation corresponding to [that mode's] essence or its degree of power' (Deleuze 1988c: 98). Thus, an *existing* mode is defined by a specific ratio of motion and rest between extensive parts. Contrary to their eternal modal essences, modes in existence must strive to persevere in their being – the now-familiar *conatus* – which means maintaining their respective ratios of motion and rest for as long as they are able.

For Spinoza, existence is a great field of encounters between modes driven by their *conati*. The outcome of a given encounter is by no means guaranteed to be favourable to a mode's longevity. As Deleuze (1988c: 100) puts it, 'existing modes do not necessarily agree with one another.' When two modes meet, the encounter is determined by their respective capacities to affect and to be affected by one another. Modes 'agree completely if their characteristic relations and extensive parts can be preserved while being combined' (Armstrong 1997: 65). An encounter between modes *x* and *y* is good if the way *x* is affected by *y* 'bring[s] about the preservation of the proportion of motion and rest [*x*'s] parts have to one another' (Spinoza 1996: 137).

A less fortuitous encounter, however, would destroy a mode in one of two ways. The first option is to accelerate or decelerate a mode's extensive parts beyond the limits of its ratio of motion and rest, such as when an animal dies of hypothermia. The second option is to remove a mode's parts altogether, death by guillotine, for example. In either case, a mode is destroyed when its parts are 'determined to enter into [new relations] not compatible with the preservation of former ones' (Armstrong 1997: 66). Once again, the fact that parts retain their own capacities to be affected by modes other than the one they currently compose, that they are 'open to the exterior' (Deleuze 1988c: 100), is what makes modes vulnerable to destruction.

It is in the context of modal encounters that Spinoza introduces an important concept that I have already mentioned in chapter 2: the concept of *affect*. When a mode is affected, its 'power of acting is increased or diminished, aided or restrained' (Spinoza 1996: 70). An affect is the passage from a lower to greater power of acting, or vice versa. Increases to a mode's power of acting are called joyful affects, while decreases are called sad affects (Spinoza 1996: 77). With this concept, Spinoza effectively argues that, for every *conatus*, there is a quantitative range in which it can strive, now with greater, now with lesser power of acting. As a consequence, modal encounters are defined not just by a capacity to affect relating to a capacity to be affected, but also by a fluctuation in the affected mode's power of acting, or 'force of existing' (Spinoza 1996: 123).

Spinoza's 'practical philosophy,' as Deleuze (1988c) calls it, consists in part of navigating existence with the aim of minimizing sad affects and maximizing joyful ones. Far from avoiding encounters in which a mode is affected, Spinoza (1996: 137) argues that modes in general, and human beings in particular, should seek out encounters that '[render them] capable of being affected in a great many ways, or of affecting other [modes].' The *conatus* leads to 'a tendency to maintain and maximize the ability to be affected' (Deleuze 1988c: 99) so that a mode can open itself up to more encounters, even if these occasionally result in sad affects. Thus, a mode's highest obtainable good is to express all its capacities – to affect and to be affected – as far as it is able.

In regard to the question of resistance, Spinoza's *conatus* and the concept of affect help us understand why a being – we could just as well call it a mode or a force – resists entering into certain relations as well as why it might resist in a power relation. In her commentary on Spinoza, Françoise Proust (1997: 16) maintains that a mode 'resists, to the best of its ability, that which endeavours to lessen or *a fortiori* to destroy its [*conatus*].' Under this guise, resistance consists of a mode's efforts to ward off sad and destructive encounters. If, as Spinoza (2007: 195) writes in the *Tractuc-Theologicus Politicus*, 'fish are determined by nature to swim and big fish to eat little ones,' then Proust (1997: 16-17) adds that 'the small fish is determined by nature to resist to the best of its abilities the big fish's efforts to eat it.' For the small fish, resistance would include a variety of strategies to thwart predatory attacks: swimming away, finding shelter, banding together with other small fish to form a defensive unit, to name a few. In this instance, resistance would be existential, with forces resisting existential threats to their *conati* from others that strive to overcome those acts of resistance, all in a literal game of cat and mouse.

While the *conatus* determines a mode 'to resist external [forces] that threaten to destroy it' (Armstrong 1997: 68), Proust also acknowledges that Spinoza's theory of affects points to another kind of resistance, namely, a mode's tendency to resist sadness, understood as a decrease in its power of acting. Resistance of this kind would involve avoiding relations that are known to produce sad affects, but it would also include strategies to inhibit undesirable relations as well as strategies to recover from a sad affect. Concerning this final point, Spinoza (1996: 120) argues that '[a]n affect cannot be restrained or taken away except by an affect opposite to, and stronger than, the affect to be restrained.' Sad affects can only be overcome by joyful affects of equal or greater magnitude. Therefore, for a mode to resist the sadness it has suffered, it must form new relations that produce joyful affects in order to regain its power of acting.

By ascribing to each force, mode, or being, an affective range, we can understand why the affected force in a power relation resists to varying degrees, according to the quality of the affect that it undergoes. Relations in which a force is affected with joy should garner little resistance, while a saddened force resists to restore its power of acting. If we revise our previous formulations to include affective fluctuations, it could be expressed as:

i. (Capacity to Affect$^{\textit{Force a}}$ —— Capacity to be Affected$^{\textit{Force b}\downarrow}$) ← Resistance$^{\textit{Force b}}$ = Force *c*

ii. (Capacity to Affect$^{Force\ c}$ —— Capacity to be Affected$^{Force\ a\uparrow}$) ← Resistance$^{Force\ a}$ = Force *d*

All I have done is add arrows (↓ ↑) to indicate affective increases and decreases in the affected force. In this example, forces *a* and *b* produce a force *c* that has the capacity to affect *a* in such a way that its power of acting is increased (*Force a*↑*,* in ii.). Unfortunately, it comes at the expense of *b* which is saddened by its relation to *a,* (*Force b*↓*,* in i.). Thus, we are dealing with a quintessential case of exploitation, where one's suffering contributes to another's advantage.

The question is, what is force *b* to do, how is it to resist? If it is able, *b* could distance itself beyond the reach of *a*'s capacity to affect so that the relation cannot be repeated. However, such a strategy of retreat, or evasion, is only available to forces with unencumbered mobility. What is more, *b*'s power of acting remains diminished until it experiences an equal or greater amount of joy. Another option would be for *b* to ally itself with another force that shields it from *a*'s capacity to affect or even forms a new force with *a* that can affect *b* joyfully.

Instead of:

(Capacity to Affect$^{Force\ a}$ —— Capacity to be Affected$^{Force\ b\downarrow}$) ← Resistance$^{Force\ b}$ = Force *c*

There could be:

i.(Capacity to Affect$^{Force\ a}$ —— Capacity to be Affected$^{Force\ x}$) ← Resistance$^{Force\ x}$ = Force *y*

ii.(Capacity to Affect$^{Force\ y}$ —— Capacity to be Affected$^{Force\ b\uparrow}$) ← Resistance$^{Force\ b}$ = Force *z*

The mediation of force *x* has the effect of turning a sad encounter into a joyful one for *b*. It is equally possible that force *y* has no capacity to affect *b*, meaning that *b* no longer experiences any affective fluctuations from either *a* or *y*.

Alternatively, the saddened force *b* can attempt to weaken the affecting force by subjecting it to sad affects as well. There are two ways of executing this strategy. Similar to the example immediately above, *b*'s first option would be to recruit a mediating force that could produce a force that can affect *a* with sadness:

i. (Capacity to Affect$^{Force\ a}$ —— Capacity to be Affected$^{Force\ l}$) ← Resistance$^{Force\ l}$ = Force m

ii. (Capacity to Affect$^{Force\ m}$ —— Capacity to be Affected$^{Force\ a\downarrow}$) ← Resistance$^{Force\ a}$ = Force n

The intervening force *l* not only shields *b* from force *a*’s capacity to affect*,* it also produces a force *m* that can sadden *a*.

If an external mediating force is unavailable, *b*’s second option is to increase its resistance through its own power of acting alone such that it alters the nature of the emergent force *c*. Looking at the original scenario one more time, we see that *b*’s capacity to be affected and its resistance are parts of *c*:

i. (Capacity to Affect$^{Force\ a}$ — **Capacity to be Affected**$^{Force\ b\downarrow}$) ← **Resistance**$^{Force\ b}$ = Force c

ii. (Capacity to Affect$^{Force\ c}$ —— Capacity to be Affected$^{Force\ a\uparrow}$) ← Resistance$^{Force\ a}$ = Force d

Consequently, the fluctuations in both *b*’s capacity to be affected and its ability to resist would change force *c* and, by extension, its affect on *a*. If *b* increased its resistance, it might not be enough to produce an altogether different force with capacities different to those of *c*, but it could produce a stronger or weaker force *c* that can affect *a* with less joy than it previously experienced. Were this the case, we could say that *b* is hampering or frustrating *a*’s empowerment without actually reversing the relation of exploitation:

i. (Capacity to Affect$^{Force\ a}$ — Capacity to be Affected$^{Force\ b\downarrow}$) ← (↑Resistance$^{Force\ b}$) = Force c’

ii. (Capacity to Affect$^{Force\ c'}$ —— Capacity to be Affected$^{Force\ a\uparrow}$) ← Resistance$^{Force\ a}$ = Force d ’

The increase in *a*’s power of acting when affected by *c*’ is less than when it was affected by *c*. We could also imagine that *b*’s resistance is so great that it produces a different force with new capacities:

(Capacity to Affect$^{Force\ a}$ — Capacity to be Affected$^{Force\ b\downarrow}$) ← (↑Resistance$^{Force\ b}$) = Force g

This new force *g* could well produce sad or joyful affects in both *a* and *b*, or not affect them at all.

Throughout this discussion, the key insight is that resistance is a variable in the production of emergent forces, i.e. power relations, a variable to be managed, rather than something external to power that must be suppressed. Sometimes more resistance is desirable for the affecting force because it produces an emergent force able to affect it with greater joy. In other instances, the affected force's resistance must be contained to a minimum. Instead of a zero-sum game between power and resistance, there are countless combinations of capacities and resistances of varying magnitudes that produce a multitude of forces with different capacities and powers of acting. The only way to determine how much resistance is necessary, tolerable, or intolerable for the production of specific forces is through continuous experimentation.

Before I can relate this atypical theory of resistance back to the question of proletarianization and FabLabs, first, I must situate it in the ontological framework presented in chapter 1. Thus far, I have used terms such as 'force' and 'mode' to stay true to the texts of Foucault and Spinoza, terms that I have already suggested are similar to what I call a being, but there are some crucial differences between them that must now be addressed.

iii. Resistance and Capacity-based Ontology

As I argued in chapter 1, a being exists in the four registers of the real: the virtual, the intensive, the actual, and the phenomenological. Each and every being is a set of virtual capacities, an intensive individual, an actual entity, and a phenomenological realm. Moreover, beings are composites of other beings (barring elementary particles), such that most beings are simultaneously 'wholes' in relation to certain beings and 'parts' in relation to others. Just as forces emerge from the relations between other forces, beings emerge from the relations between other beings. And like forces, beings cannot exist independently of their parts; the latter are the immanent cause of the former. Nevertheless, a being distinguishes itself from its parts by expressing a different set of virtual capacities.

Where can we situate Foucault's analytics of power and Spinoza's affect theory in this ontology? If we think of forces from the ontological perspective developed by Deleuze in *Difference and Repetition*, with its tripartite structure of the virtual, the intensive, and the actual, they clearly belong to the intensive register of the real. Foucault (1978: 93) writes of a 'moving substrate of force relations which, *by virtue of their inequality*, constantly engenders states of power' (emphasis added). This resonates strongly with Deleuze's claim that the difference in intensive quantities, the fact that they are unequal, is the productive motor of the real that connects the virtual to the actual.

Foucault (1978: 94) – who does not use terms such as virtual, intensive, or actual – prefers to say that the 'manifold relationships of force...take shape' in all the entities, processes and relationships that exist in society, nature and the cosmos. Each human, biological, or physical being is both an expression of a force and the effect of immanent power relations between other forces. Such power relations are 'the internal conditions of [the] differentiations [that produce individual entities]' (Foucault 1978: 94), a claim that is equally suitable for Deleuze's intensities. Given these parallels, I argue that Foucauldian forces belong to the intensive register of the real. In effect, a force is equivalent to an intensity or an intensive individual. The major difference, however, is that I follow Deleuze in positing a virtual realm that is distinct from the intensive, a realm of virtualities, or sets of capacities as I call them. Thus, *forces express virtual capacities at varying degrees of intensity*.

It is also possible to connect Spinoza's modes and affects to my fourfold ontology. To recap, a being for Spinoza is first and foremost a modal essence, a degree of power in the eternal substance of God or Nature. A modal essence corresponds to a specific 'ratio of motion and rest' (Spinoza 1996: 43) between other modes. When existing modes are determined to 'communicate their motions to each other' (Spinoza 1996: 42) in accordance with its ratio, a modal essence passes into existence. Once a mode exists, it strives to persevere in its being, undergoing a series of encounters with other modes that are determined by their capacities to affect and to be affected. When a mode is affected, it can either experience an increase in its power of acting, i.e., a joyful affect, or a decrease in its power of acting, i.e., a sad affect. Finally, a mode ceases to exist when its ratio of motion and rest is no longer actualized and its power of acting drops below its minimal limit. Despite this existential death, the modal essence remains eternal in the infinite power of God.

Reinterpreted through my lens, I could state that a modal essence correlates to a being's virtuality, the ratio of motion and rest to an intensive individual, and the existing mode in extension to an actual entity. Affects, as I have already stated in chapter 2, are intensive transitions undergone by intensive individuals within a certain range that corresponds to their virtual sets of capacities. Be that as it may, the major distinction between Spinoza's modal essences and my understanding of virtualities, adapted from Deleuze (1994) and Bryant (2011a), is that the former are eternal while the latter are historical. Spinoza's essential realm is fully formed because he posits an omnipotent, omniscient, all-encompassing God that subsumes all possible modal essences, regardless of whether they come into existence or not. Meanwhile, I follow Deleuze (1994) who posits a virtual without a God; a virtual that is made, and immanent to the rest of the real.

Having established that forces and affects are intensive concepts, the question remains as to how resistance fits into my ontological framework. In the previous subsection, I argued that resistance is a variable internal to the production of emergent forces, which is to say that *resistance is internal to invention*. A force, or power relation, consists of a relation between two capacities – a capacity to affect and a capacity to be affected – as well as the resistance of the affected force. Given that the capacities expressed belong to the virtual, it is plausible that resistance also originates in the virtual as a third capacity: the *capacity to resist*. During his year-long seminar series on Foucault at the Université de Paris VIII, Deleuze (1986) proposes this theory of virtual resistance, or resistance as a capacity, as one of Foucault's major philosophical contributions:

> I can no longer say, as I have said so far, that there are relations between two powers, namely, the power to affect and the power to be affected. I am obliged to include a third power: the power to resist (*pouvoir de résister*)...It is a third kind of singularity...That there is a power to resist that wouldn't be reduced to the power to affect, nor the power to be affected, this is Foucault's discovery.

If we follow Deleuze's reading of Foucault, intensive forces would now express three kinds of virtual capacities (or singularities in Deleuzian terms): the capacity to affect, the capacity to be affected, and the capacity to resist. This theory of resistance allows us to better understand an earlier scenario in which I proposed that the affected force increases its resistance so that the emergent force changes.

First, the original scenario, now amended to include the capacity to resist:

i. (Capacity to Affect$^{\textit{Force a}}$ – Capacity to be Affected$^{\textit{Force b}\downarrow}$) ← Capacity to Resist $^{\textit{Force b}}$ = Force *c*

ii. (Capacity to Affect$^{Force\ c}$ – Capacity to be Affected$^{Force\ a\uparrow}$) ← Capacity to Resist$^{Force\ a}$ = Force *d*

The revised scenario, with increased resistance:

i. (Capacity to Affect$^{Force\ a}$ – Capacity to be Affected$^{Force\ b\downarrow}$) ← ↑Capacity to Resist$^{Force\ b}$ = Force *c*'

ii. (Capacity to Affect$^{Force\ c'}$ — Capacity to be Affected$^{Force\ a\uparrow}$) ← Capacity to Resist$^{Force\ a}$ = Force *d* '

To get from the original scenario to its revised version, we have to establish how force *b* manages to increase its capacity to resist, i.e., how it manages to resist with more intensity. One possibility is that *b* can actively manage its power of acting, redistributing it between its three capacities as it sees fit. However, this would effectively turn forces into subjects, a highly problematic proposition. The Spinozist could argue that this transfer occurs automatically, in accordance with the tendency for things to strive to persevere in their being. Finally, we could also assume that there was an intervening encounter in which *b* underwent a joyful affect that increased its overall power of acting. I prefer this last option because it assumes the least. It also does not exclude the possibility of auto-affection, whereby a force can affect itself with joy, mobilizing greater resistance without appealing to external forces; hence why it is important to think of power primarily as a relation between capacities, rather than between forces.

Regardless of how *b* increases the intensity of its resistance, I contend that it is overly reductive to limit our understanding of resistance to a virtual capacity to resist. As we saw, there are so many other strategies that can be employed to reverse, alter, limit and prevent the emergence of new forces. These strategies also deserve to fall under the concept of resistance. At its core, resistance is about placing restrictions on the interactions between intensive forces by mobilizing and configuring all three types of capacities in local arrangements. There are countless specific reasons for resisting, but ultimately it comes down to impeding the emergence of certain forces, certain capacities, and limiting the occurrence of certain affects. What those forces, capacities, and affects may be, depends entirely on local contexts and the beings involved. In the next section, I will explore the implications of this theory of resistance for the question of proletarianization and the de-proletarianizing potential of the FabLabs.

II. Proletarianization and Resistance

An important takeaway from the preceding theoretical discussion is that we can no longer content ourselves with a binary opposition between power on one side and resistance on the other. Resistance is an intrinsic variable in the production of power relations, i.e., the relations between capacities activated by intensive individuals which produce new individuals with new capacities. In the previous chapter, I called the activation of new capacities invention. Thus, resistance is a variable that is internal to invention, but invention can also activate new capacities to resist. Whereas the capacities to affect and to be affected enable intensive interactions, the capacity to resist restricts intensive interactions without stopping it entirely.

Resistance, however, is not limited to a virtual capacity. I define resistance broadly as that which places restrictions on intensive interactions. Indeed, we must abandon the idea that resistance is inherently subversive, critical, or tied to the oppressed, and treat it instead as a set of strategies that can be used towards a myriad of ends. Undoubtedly, resistance can subvert hegemonic forces, but it can also serve them. I argue that certain strategies of resistance have the effect of inhibiting invention and therefore contribute to the problem of proletarianization. My aim in this section is to identify those strategies.

Proletarianization is currently driven by a process in which the evolution of technological capacities far outpaces the development of the human capacities needed to participate in that evolution. Not only are the capacities of technological objects proliferating, they are also increasingly present in all facets of human existence. In and of itself, this is a welcome phenomenon. These capacities have a great transformative potential, and reflect our ability as humans to understand other beings enough to recruit them in our efforts to respond to problems big and small. Working with the plenitude of capacities belonging to the innumerable nonhuman beings that make up our world, we have been able to invent so many more beings with new and different capacities. Some of these have brought about a great deal of human and nonhuman suffering, while others have eradicated miseries and produced immense joy.

The point, however, is not to adjudicate technology as a whole, but rather to recognize that, with all these new technological beings and capacities, our social and political landscapes have been dramatically transformed into sociotechnical arrangements in which technological capacities are just as important as human capacities. If technical objects are solutions to problems, as discussed in chapter 4, they are also the conditions of new problems, many of great social and political significance. The general lack of technological literacy, a key element of proletarianization, makes it extremely difficult for those affected to formulate problems that take sufficient account of these important technological factors, let alone devise new solutions to old problems. Contrary to Stiegler, for whom the proletarian is the person who has lost their knowledge to technology, I argue that the proletarian is the person who is unable to pose problems with contemporary sociotechnical conditions.

How, then, does resistance contribute to the plight of this new proletariat? From a capacities-based perspective, proletarianization is primarily a shortage of human capacities necessary to engage with technology beyond our roles as consumers and users. Consequently, we could argue that proletarianization is driven more by non-relation than by resistance. The difference between non-relation and resistance is subtle, but crucial. Resistance occurs when there are compatible capacities to affect and to be affected that can form a new force, otherwise there is no need to resist. Put differently, a being only resists that which can affect it. If, however, forces lack the capacities to relate to one another, then they are *non-related*.

Resistance and non-relation are easily conflated, since all too often resistance assumes the appearance of non-relation. This happens when a being resists by placing an intermediary between two forces that would otherwise affect each other and form a new power relation. When something effectively shields or insulates a force from certain others, it can seem as though there is a non-relation, instead of a particular strategy of resistance. In order to differentiate the two in specific contexts, we must consider whether a lack of relation can be attributed to an interfering force or a genuine absence of compatible capacities.

On its face, proletarianization suggests a great deal of non-relation. People lack the capacities and the technological education to participate in technology's becoming, by which I mean both its evolution in terms of capabilities and its social application. Therefore, the only way to rectify this pervasive non-relation is to develop the capacities to affect and to be affected that would allow people to relate to technology more actively. Not only is this Simondon's overarching thesis throughout his *oeuvre*, it is also the guiding principle of the FabLab and maker movement. Nevertheless, to attribute proletarianization entirely to non-relation is tantamount to equating effect and cause. It loses sight of the reasons why proletarianization persists, and the strategies of resistance involved.

By maintaining that certain strategies of resistance contribute to the process of proletarianization, I am by no means claiming that there are select actors that intentionally support proletarianization as I have defined it. In other words, proletarianization is not the result of a grand conspiracy perpetrated by powerful institutions that are solely responsible for this historical event, but rather a process without a subject resulting from countless encounters, power relations, and micro-decisions. And yet, there are patterns, tendencies, and focal points that help explain how proletarianization continues to grow as a problem and why it seems to garner little public attention.

In Chapter 3, I argued that proletarianization in the Global North is intertwined with the emergence of an economic system built on the division labour, the pursuit of profit, and the threat of destitution for those who refuse to participate in it. This system called capitalism encourages us to limit our capacity development, i.e. our learning, to those enterprises that can provide us with enough money to live comfortably and enjoy some of the many things that money can buy. Technology, its development and dissemination, is viewed as a sector of the economy which, like all sectors, should be left to the management of those with the most relevant knowledge, skill-sets, and material resources at their disposal. The extent to which that knowledge and skill should be shared outside of the sector depends on the severity of the need to recruit more people to that sector, as well as other initiatives such as public education, universities, and other actors looking to spread technical knowledge beyond its enclaves in industry and academia. To further complicate this picture, the rise of nation-states and conflicting 'national' interests has also placed limitations on how far knowledge can travel. These systemic considerations still hold, but the challenge is to identify the concrete ways in which resistance functions on a variety of scales to restrict a greater democratic participation in the becoming of technology.

i. Intellectual Property Rights Revisited

The most recognizable strategy of resistance is the use of intellectual property rights to set restrictions on the circulation and use of written information, product designs, as well as audio, visual, and audiovisual material. The use of patents can delay the imitation of new designs for fixed terms, but only in certain jurisdictions, as there is no global patent enforcement system. What is more, in order to file a patent, the holder must formalize in written instructions exactly how his or her invention works and how it is made, meaning that the information is publicly available and vulnerable to unlawful replication. As a consequence, patents are not the surest way to control information, but they can certainly slow down the rate at which new technologies and innovations become more widespread, as they did in the case of 3D printing technology.

Copyrighted material has also proven to be extremely susceptible to unlicensed distribution, given the ease with which digital files can be shared online. Audio files, videos, images, texts and software programs that have restrictive copyright licenses are readily available for those who know where to find them and how to avoid criminal liability. Academic publishers are learning this the hard way as they continue to wage legal battles on websites that offer their content for free, such as LibGen and Sci-Hub. Indeed, when it comes to academic knowledge, the preferred strategy of resistance is the online paywall, as well as the exorbitant subscriptions fees that are only affordable to university libraries and other adequately financed institutions. There is, however, a growing effort to publish Open Access (OA) books and articles that are free of charge for readers. Some estimates claim that roughly a quarter of all academic publications are freely available, whether through OA journals and publishers, or the self-archiving of articles by their authors on other repositories, such as Academia.edu (Tennant et al. 2016).

Given the challenges of enforcing intellectual property rights, profit-seeking actors have increasingly turned to platform-based business models (Srnicek 2017). Instead of exchanging the good itself for money, companies can offer access to copyrighted material for a subscription fee. Unlike subscription-based academic journals, these platforms do not allow their users to download the actual digital files of the content in question, thereby precluding the possibility that said files get recirculated illicitly. Spotify for music and Netflix for television series and movies are the two most prominent examples of this trend towards selling access over goods. A similar model is increasingly common among software providers, especially for CAD software. Instead of a one-off sale for a particular program, users pay an annual or monthly subscription to run the software without ever owning it per se.

In every case, the turn to a platform-based model is a clear reaction to the growth in illicit file sharing online, and a tacit recognition from commercial actors that selling digital files is risky from a profit-seeking perspective. The platform approach has the added benefit of allowing companies to amass a great deal of data on their consumers and their consumption patterns, data that can be recycled to improve their services or sold to third-parties. Data are increasingly regarded as essential not only to staying competitive, but to the development of new algorithms and machine learning. Later in this chapter, I discuss the important dynamics between data and FabLabs.

Whereas patents, copyright licenses, and platforms can be used to ensure that the public circulation of information remains profitable to its legal owners, trade secrets are not meant to be circulated outside of a particular entity at all. The legal doctrine concerning trade secrets defines what knowledge and know-how an employee can share outside the workplace and, in the event of joining another company, what can be disclosed to the new employer. The doctrine is broad and vague, but its purpose is to protect firms from a mobile labour force that could use the knowledge acquired in one place of work to benefit another. Like most legal doctrines, it is also highly dependent on the practices of the enforcing jurisdiction. On this point, Catherine Fisk (2001: 447-448) writes:

> It has been contended, for example, that the Silicon Valley phenomenon of high labour mobility and rapid diffusion of new technology occurred in California, rather than elsewhere, for two reasons. First, California's restrictive law of trade secrets was *not* enforced as it is written. Second, California's flat prohibition on post-employment restrictive covenants was enforced *exactly* as written.'(emphasis in original)

In the same article, Fisk explains how the logic of trade secrets clashes with the legal reasoning of pre-industrial artisanal production that dealt with the transmission of trade knowledge. She states that the '[l]egal regulation of artisanal work relations explicitly contemplated that the apprentice eventually would become a journeyman or a master and, as such, would be free to use all knowledge that he had acquired' (Fisk 2001: 450). This is not to say that there wasn't any secrecy in pre-industrial production. Craft guilds mandated that their members restrict the dissemination of their knowledge to a fixed number of apprentices who, in turn, were bound to strict terms of confidentiality for the duration of their apprenticeship. The difference, however, is that the master craftsman imparted knowledge to his or her apprentice permanently for the sake of prolonging and developing his or her craft, while the firm imparts knowledge to its employees temporarily for the sake of profit.

Proponents of intellectual property rights will argue that these restrictions on the circulation of knowledge and information are necessary to encourage economic actors to produce new knowledge and new creative content in the first place. Without the legal assurance that an invention, innovation, or discovery would be the exclusive property of its author(s), private firms and individual inventors would have no incentive to invest time, energy, and resources into technological research and development, or artistic projects. As a consequence, we wouldn't have reached our current levels of technological advancement and cultural production. These claims are entirely plausible, even probable, but that does not diminish the fact that intellectual property rights are forces that inhibit the free circulation of knowledge and thus partly responsible for our state of proletarianization.

Be that as it may, we must look beyond intellectual property rights to other strategies of resistance that contribute to proletarianization. As mentioned at the beginning of this thesis, intellectual property rights rank low on the list of challenges that FabLabs face, or, we can now say, the resistances they encounter. The amount of free and open source information, tutorials, and software continues to grow, and it has already reached a point at which it would be possible to reach a decent level of technological literacy with enough time and effort. A far greater challenge is to find entry points through which the uninitiated can discover their local FabLab. One such point of entry is to host events sometimes called Hackathons or Hack-a-Thing which pin participants against another proletarianizing strategy of resistance, what I call resistance by design.

ii. Resistance by Design

A myopic fixation on intellectual property rights loses sight of the fact that consumer products in general, and technological devices in particular, are themselves carriers of information. Blueprints and design patents may carry more information about how something is made, its individual components, and how they work together to create a functioning whole, but it is still possible to learn a great deal from an object if we are willing and able to pierce through its veneer of impermeability. In our earlier discussion of Simondon's critique of the consumerist relation to technology, we saw that part of the problem of proletarianization is ideological. The consumerist disposition encourages humans to think of technological devices as immutable unities that cannot, or even should not, be altered by anyone, and should only be serviced by an accredited professional, preferably someone who works for the original manufacturer. This ideological barrier is complimented by a set of subtle design strategies that make objects resistant to change and difficult to extract information from.

FabLabs organize events that offer members of the public the opportunity to confront both of these strategies of resistance at once. Hackathons, Hack-a-thing, or Hack Cafés, are events where participants try to alter or repurpose a technological device that they purchased at some point. Hacking, in this context, does not refer to the writing of computer code, but to the act of penetrating and altering something, and is therefore closer to the popular understanding of computer hacking or computer hacker. Typically, participants bring an old appliance that has stopped working or has been replaced by a newer model. Using the tools available in the lab, participants find ways to salvage parts for a new object altogether or introduce new parts to give the old appliance new functionalities. FabLabs also host Repair Cafés where the focus is, as the name suggests, on fixing broken appliances or devices, rather than repurposing them.

In either case, these events are significant because they force participants out of their familiar roles as consumers and users, who only engage with a fraction of the total object, into explorers of the manifold that exists within every technological being. Yet, one of the first lessons learned by anyone attempting this journey is that intruders are most unwelcome. In fact, the hostility can be striking. Appliances and devices are frequently designed to be opened up by specialized tools and, sometimes, not at all. To illustrate this resistance by design, I use two examples taken from my personal experiences. First, let me reiterate that my technical know-how is extremely limited, so these case studies are quite low-tech, but no less indicative of how consumer products are designed to be impenetrable. Second, I confess to being rather fond of food and drink, so it should come as no surprise that both of these examples relate to kitchenware, namely, a coffee grinder and a pepper mill.

Coffee aficionados like to say that a good grinder is just as, if not more, important than a good espresso machine. As a postgraduate student living in London, I could afford neither of these things. Nevertheless, I invested a total of about £150 on an entry-level grinder and machine, telling myself that I would ultimately save money by cutting down on the number of trips I took to specialty coffee shops. I was well on my way to becoming my own barista when I ran into a serious problem. My new conical burr grinder could not grind finely enough for my machine to spit out a decent shot of espresso. No matter how forcefully I packed the basket, the coffee came out watery and devoid of crema, that brown layer of foam that rests upon the liquid as a sign of a successful extraction.

My options were to return the grinder and buy a significantly more expensive model, give up the dream, or to find a way to get the thing to cooperate. I didn’t have the money for something more expensive and I couldn’t return the espresso machine that I had bought second hand, so I was left with option number three. Fortunately, and predictably, I was not the first to confront this dilemma, as confirmed by a cursory google search. The solution was to alter the factory settings on the grinder by adjusting the internal mechanism that determined the proximity of the two burrs as they spun. However, the only apparent way to access this internal mechanism was by unscrewing two screws that sat deep in the machine’s underside. Not only were these screws unreachable by any screwdriver I had ever seen, they also had heads that didn’t match any of the common screwdriver tips sold in hardware stores. Clearly, the grinder had been designed to ensure that only people with access to extremely specific screwdrivers could access its interior.

It took a decent amount of brute force to overcome the resistance built into machine, but ultimately I was able to access the grinder’s interior. By following the advice I found online, and with a great deal of trial and error, I was able to make the desired changes. As satisfying as that first drinkable espresso was, the experience was a harsh lesson in the lengths that manufacturers will go to limit the consumer's access to their products. I was therefore less surprised when, a year or so later, I had my second clear encounter with designed resistance.

This time, it was a simple pepper mill bought at a supermarket in Budapest. The mill was perfectly functional, up until I wanted to reload the peppercorn. Incredibly, the mill had been designed to look as if it could be refilled when, in fact, it could not. Yet again, a product was made so that its interior was off limits to consumers. In the case of the pepper mill, the commercial motivations behind this design choice were transparent, a kind of planned obsolescence that forces the consumer to buy an entirely new unit, despite the fact that the mill technically worked without issue. But thanks to a kitchen knife and some perseverance I was able to carve out a path that allowed me to refill and reuse the mill well beyond its intended lifespan. In both cases, the resistance designed into these products did not negate the fact that they still possessed capacities to be affected that the manufacturers did not want to be actualized; it just made actualizing those capacities more difficult and less likely.

Trivial as these examples may be, they connect to a broader trend in the manufacturing of technology. Apple, the largest tech company in the world, uses 'proprietary screws, unibody enclosures, and other manufacturing and design techniques that make it so only Apple or computer repair experts can easily take them apart' (Statt 2017). The batteries in their smartphones are nestled deep in the units and glued to sensitive parts so that customers have no choice but to upgrade to a newer model once their phone's battery life starts to wane. Apple isn't alone in making their products more difficult to repair or alter. Samsung, Sony, LG, John Deere, and Hewlett Packard (HP) have also been singled out by organizations fighting for the 'Right to Repair' (Wiens & Gordon-Byrne 2017). Companies increasingly withhold information, such as repair manuals and exploded-view diagrams that show a product's individual parts, how they fit together, and how to troubleshoot common problems, on the grounds of protecting their intellectual property and ensuring the safety of their products (Schaffer 2017).

In response, groups such as Repair.org and iFixit have tried to fill the information gap by creating their own guides on how to repair popular devices and appliances. They have also lobbied governments to adopt ‘Right to Repair’ legislation, such as the Fair Repair Act that was considered by the New York state legislature in 2015. Three years on, that particular effort has been shelved, largely due to a counter-lobbying campaign by tech companies. Nevertheless, similar bills are currently being debated in other American states, with an especially promising piece of legislation in Washington state that would ban the sale of ‘hard-to-repair’ devices (Locklear 2018). The activists involved hope to do for electronics what was done for automobiles when the state of Massachusetts passed a law in 2013 that made it illegal for car manufacturers to withhold repair information from independent repair shops, a move that resulted in a change of corporate policy nationwide.

When FabLabs organize Hack-a-thing or Repair cafés, they implicitly relate the mundane objects of people’s everyday lives to these wider political struggles. Participants discover, as I did, that many of the products they own have been designed to resist certain interactions, not out of concern for the integrity of the product, but out of a cynical concern for repeated custom. Once that resistance is overcome, they are able to experiment with capacities to affect and to be affected that exist within the object and in its parts. FabLabs are also extremely useful when it comes to producing replacement parts that may or may not be available for order from the original manufacturer. One research participant said that needing a replacement part of an appliance was the catalyst for his experimentation with 3D printing and getting involved with the FabLabs (Interview 3).

Although the debate surrounding the ‘Right to Repair’ and planned obsolescence is typically framed as an ecological problem (cf. Rivera & Lallmahomed 2016; Schaffer 2017; Guiltinan 2009), and for good reason, given the ever growing amount of electronic waste across the globe, there are also important political and ontological issues at play. Ontologically, making an object resistant to consumer interventions reinforces the idea that it is a totalizing whole, a singular being that has no other capacities than those advertised. This anti-pluralism carries political implications. We do not realize that participation in the becoming of technology is not limited to those select few who work for tech companies, nor that the devices and appliances around us are carriers of information and capacities that we can use to pose and solve problems, and invent new sociotechnical beings.

III. Data, De-proletarianization, and Sociotechnical Associated Milieus

Increasingly, the strategy of resistance by design involves the use of proprietary software as more and more commonplace items are becoming *smart*, i.e., controlled by microchip computers. Consequently, even if you are able to overcome a product's physical resistance and access its interior, you might encounter digital barriers to making alterations and repairs. With the *smartification* of material objects and the *Internet of Things* upon us, it is clear that overcoming these forms of resistance will require more than brute force and sharp knifes. In the following section, I address the current and potential roles that FabLabs can play in ensuring that this ongoing technological transformation does not repeat the proletarianizing tendencies of those before it.

i. Data and the Internet of Things

Terms like the data economy, big data, and the Internet of Things are gaining traction both in public and academic discourses, eliciting a range of reactions from jubilation to outright paranoia, and everything in between. Rarely, however, do such assessments start with a sober specification of what is meant by the word *data* (datum singular). One such exception is Nick Srnicek (2017: 39), who writes:

> it is important to be clear about what data are. In the first place, we will distinguish *data* (information that something happened) from *knowledge* (information about why something happened). Data may involve knowledge, but this is not a necessary condition. Data also entail recording, and therefore a material medium of some kind. As a recorded entity, any datum requires sensors to capture it and massive storage systems to maintain it. Data are not immaterial, as any glance at the energy consumption of data centres will quickly prove (and the internet as whole is responsible for about 9.2 per cent of the world's electricity consumption).

While I do not share his definition of knowledge, I agree with Srnicek that data are, first and foremost, mnemonic markers that are not inherently meaningful for human beings. Equally important is the recognition that data are dependent on a material infrastructure for capture and storage. Perhaps the biggest technological factor in recent decades has been the exponential growth in the capacity to store digital data on ever smaller drives, a capacity that continues to grow at about 175 per cent annually (Mearian 2014). As a consequence, there is no tangible limit to the amount of digital data that we can store and it is easier than ever to place data storage devices and sensors into practically anything. These small computers, known as microcontrollers, are what make a device *smart*. They also need to be programmed, and it is their operating source code that companies can withhold from consumers on the basis that they are protecting their intellectual property. Often, this means that the data amassed by the device is withheld as well.

Data that are contained within a device might help it to function better, but the next technological step has been to give devices the capacities to send and receive data across networks. Much like our smartphones are connected to the Internet, the Internet of Things generally refers to networked devices exchanging digital data. Although it is still in its infancy, the transformative potential of this ongoing development should not be understated. In fact, it is precisely because it is in its infancy that it deserves far more public attention than it currently receives.

Due to its name, one would assume that the Internet of Things would emulate the Internet itself as a decentralized network governed by a common protocol – the Internet Protocol (IP) – that facilitates the inclusion of new nodes and simplifies communication across the network. Regrettably, this assumption is misguided. Instead, big tech companies are racing to develop their own proprietary communication standards in the hopes that they can extract a form of rent from their clients which, for now, are other big companies, but will soon reach retail customers (Gershenfeld & Vasseur 2014). The customers would buy and own the devices, but they would have to pay a subscription fee for access to the platform that manages the network's many data streams. Moreover, companies could then reserve the right to store all data on centralized servers that they alone control and monitor. It is against this backdrop that FabLabs and the broader maker movement emerge as important players to resist this proletarianizing trajectory.

When they aren't 3D printing or laser cutting, the more adept members of the FabLabs that I researched would likely spend their lab time programming microcontrollers that they had placed in unsuspecting objects. At first, I found this desire to computerize and connect everything slightly disconcerting. If I asked people why they were putting microcontrollers in things, they often replied that it was out of curiosity or just to see if they could. With the mantra-like quality of Gershenfeld's (2005) oft cited quote, 'turning data into things and things into data,' I began to question this apparent compulsion to capture and store data. Makers were producing a lot of data without seeming to know what to do with it.

This suspicion was also conveyed by Niels Boeing, one of the co-founders of Fabulous St Pauli. For Boeing, the need to turn everything into a site of data capture, storage, and exchange not only demands a greater understanding of what the data are for, it runs the risk of "excluding a broader public. I'd be more interested in making things easier, simpler, and more accessible to the low-tech community," he adds, "only use electronics when it is absolutely necessary, not just because you can" (Interview 7). The maker movement's inclination to make all things *smart*, he argues, must be moderated by the desire to reach a broader low-tech public.

While I still share Boeing's concern that FabLabs need to do more to reach low-tech communities, I now recognize the importance of the experimentation that makers are conducting with microcontrollers and the data they produce. Rather than the actual data and their utility, what matters most is that they are developing an alternative to the proprietary Internet of Things. Their use of free and open source microcontrollers, software, and the same protocol as the Internet (IP) demonstrates that the inventive capacities at their disposal are remarkable because they are working with the de-centralized and inclusive logic of the Internet, not against it. By encouraging participation in the evolution of a technological transformation in its early phases, FabLabs are helping to create people who are able to problematize and engage with that transformation before proletarianizing forces take hold of it. De-proletarianization in action.

Data are equally important to the FabLabs in their efforts to develop a robust network of information and design exchange, where a project realized in one lab can be taken up by another. The long term survival of the FabLab network depends on the production, storage and exchange of meaningful data that others can use to make things, CAD files for example, and cultivate new skills, such as tutorials on software programs and 3D printing. Hence the crucial need for users to document their work and share it online. As previously mentioned, documentation has proven to be a difficult responsibility to enforce. More than just a matter of network integrity, however, the question of documentation points to another key facet of de-proletarianization: the need to problematize the FabLab itself as a social and political being.

ii. FabLabs as Political Problems & Sociotechnical Associated Milieus

Thus far, I have focused almost exclusively on the technological aspect of proletarianization and de-proletarianization. I have emphasized that technological illiteracy is a core component of the proletarian's inability to pose and solve problems that affect social, political, and economic life, because the conditions of these problems are increasingly technological. True as that may be, there is also a political dimension to proletarianization that is just as crucial, if not more so. De-proletarianization cannot be reduced to technological instruction or what public authorities refer to as 're-skilling' (World Economic Forum 2018). Nor does it mean looking for strictly technological solutions to all problems. Instead, it means recognizing that politics are always sociotechnical, consisting of the interactions between capacities residing in both human and nonhuman beings.

Beyond the cultivation of a properly sociotechnical sensibility, de-proletarianization must enable participation in the co-evolution of technology and society. This work must include the lab itself as a heterogenous entity made of humans and technological beings. Not simply as a container in which these beings interact, but as a being in becoming that evolves in tandem with its parts. A FabLab is a political problem insofar as it exerts a downward causal influence on its parts, promoting the expression of certain capacities while discouraging others. Who decides which capacities are enabled and which are suppressed, and how?

In the previous chapter, I explained that each FabLab has its own unique political structure. Of the three labs that I researched in depth, the Petit FabLab de Paris has the most inclusive organizational structure, FabLab Budapest the most exclusive, and Fabulous St Pauli somewhere in between. Based on my research, I can say that the general tendency in European grassroots labs is to restrict organizational decision making to a core group, typically those who founded the lab. Given that lab founders tend to invest out-of-pocket for equipment and rent, it is understandable that they monopolize all decision making in the early phases of a lab's existence.

Problems start to arise, however, when a lab's political structure fails to evolve as it expands in membership. New members are effectively cut out of the political life of the lab and its decision making processes. In so doing, labs reproduce the organizational structures of other non-democratic institutions that restrict their members' abilities to problematize the conditions under which they learn, live, and work. The FabLabs that fall under this category, and there are many, ultimately reinforce the false distinction between technology and politics that underpins proletarianization.

What is more, centralized decision making structures hamper a FabLab's ability to become what Stiegler (2010: 51) calls an 'associated sociotechnical milieu.' Inspired by Simondon's definition of an associated milieu – a milieu that is co-constituted with a technical individual and ensures its survival – a 'sociotechnical' associated milieu suggests a milieu that is shared by technical individuals and social individuals, machines and humans.

Rather than social individuals, however, Stiegler embraces Simondon's theory of psychic and collective individuation. Simondon (2007; 2009) argues that psychic individuations, i.e., the becoming of individual human beings, are inextricably intertwined with collective individuations, namely, the becoming of groups and societies. The singular human being individuates, or becomes, by acting on an outside world and 'represent[ing] its actions through the world to itself as an element and as a dimension of the world' (Simondon 2009: 8). This self-perception of the human elicits internal (psychic) transformations which we have already seen is an essential aspect of learning. Thus, a human being can only change internally, i.e., *learn*, by changing its outside environment and, in so doing, contribute to the individuation of a collective.

Proletarianization, Stiegler (2010a: 38) argues, impedes psychic and collective individuation, or what he calls 'transindividuation,' in the workplace by 'short-cuit[ing] the processes...through which, by becoming individuated through work, that is, through learning something, the worker individuates the milieu of their work.' Whether it is at your nearest fast-food franchise, or in the distant call centre, workplaces are designed to be indifferent to their workers beyond facilitating the explicit tasks they are paid to perform. The worker is dissociated from the workplace and therefore unable to individuate psychically and collectively.

Meanwhile, an associated sociotechnical milieu is an environment in which psychic, collective, and technical individuation all take place. What this means tangibly is a milieu that enables learning by maximizing its capacities to be affected by the human and nonhuman beings it encompasses. If the ‘self can trans-form itself psychically only to the extent that it trans-forms its social milieu’ (Stiegler 2015a: 58), then learning requires a malleable environment. However, the question remains as to how a milieu’s receptivity encourages learning and de-proletarianization, specifically in the context of my capacities-based ontology.

In chapter 1, I followed Deleuze (1994) in defining individuation as an intensive process undergone by an intensive individual in a field of individuation. Given Simondon’s influence on Deleuze, it is not surprising that he too describes individuation in intensive terms. For Simondon (2009: 5), individuation emerges from a ‘[pre-individual] system that contains potentials and encloses a certain incompatibility in relation to itself.’ A pre-individual system laden with potentials is precisely what Deleuze (1994) calls the virtual, although we must tread carefully not to conflate the two thinkers entirely. Simondon does not share Deleuze’s theory of the virtual. In fact, he argues that ‘[t]he notion of virtuality must be replaced by that of a system’s metastability’ (Simondon 2007: 210). A system is metastable when it reaches an equilibrium without having exhausted all of its potential for transformation. The metastable differs therefore from a stable equilibrium:

> stable equilibrium excludes becoming, because it corresponds to the lowest possible level of potential energy; it is the equilibrium that is reached in a system when all of the possible transformations have been realized and no more force exists. All the potentials have been actualized, and the system having reached its lowest energy level can no longer transform itself.
>
> (Simondon 2009: 6)

In thermodynamic terms, the stable equilibrium is a high entropy state in which no new work can be done because all intensive differences have cancelled each other out. A metastable equilibrium, on the other hand, is an extremely precarious equilibrium that breaks with ‘the least modification of system parameters (pressure, temperature, etc.)' (Combes 2013: 3). Thus, to say that pre-individual being is metastable is to say that it is in a state of tension that is highly charged. The tension in pre-individual being is due to the fact that it 'harbors potentials that are incompatible because they belong to heterogeneous [orders of magnitude]' (Combes 2013: 4). Individuation, according to Simondon (2009: 5), 'must therefore be considered as a partial and relative resolution that occurs in a system that contains potentials and encloses a certain incompatibility in relation to itself.'

All of this sounds very similar to Deleuze's ontology, with the important caveat that Simondon makes no distinction between the intensive and the virtual. Deleuze argues that (1994: 246) 'individuation is essentially intensive, and that the pre-individual field is a virtual-ideal field.' The pre-individual virtual Idea does not individuate or actualize itself, but requires intensive differences to determine its individuation and actualization. Meanwhile, Simondon argues that the pre-individual metastable system triggers itself to individuate. As Combes (2013: 4) explains, 'it is owing to [the] tension and incompatibility between potentials harbored within the pre-individual that being dephases or becomes, in order to perpetuate itself.' While I agree with Deleuze that the virtual and the intensive should be distinguished, that the virtual structures the intensive, Simondon nevertheless offers important insights on the intensive register of the real.

For one, Simondon's notion of a metastable system elucidates the nature of the fields of individuation and intensive individuals. An intensive individual is the partial expression of a set of virtual capacities in an intensive environment. The virtual capacities that the individual activates and incarnates give it a certain stability, a relation between intensive parts that differentiates it from its field of individuation. But far from a stable equilibrium with no ability to transform, the individual is in a state of metastable equilibrium, prone to fluctuations and transformations, i.e. affects, caused by its interactions with its intensive field. It is this metastability that gives the individual its dynamism without losing its individuality. Intensive individuals are also metastable in the sense that they hold within a certain intensive range marked by critical thresholds. Beyond those thresholds new individuals emerge that incarnate other sets of virtual capacities, new metastable systems at higher or lower degrees of intensity.

Metastability can also be attributed to the field of individuation itself. More precisely, an intensive environment must be metastable to give rise to individuation. Here, we can understand why Simondon conflates the virtual and the intensive in his use of the term *pre-individual*. Strictly speaking, there is an intensive environment that temporally precedes an individuation and the individual that undergoes that process. The intensive environment is pre-individual in the sense that it exists prior to the individual. I find this misleading, however, as the intensive environment that is anterior to a particular individual is already populated by other individuals.[9]

Following Deleuze and Guattari (1987: 256), I maintain that intensive individuals are composed of 'intensive parts,' those parts being other intensive individuals that have entered into composition with each other. Thus, individuation involves the interactions of individuals of varying degrees of intensity that were previously disconnected. The nascent individual that emerges from this process comes to mediate those interactions, according to the virtual capacities it activates. This is why Simondon (2009: 6) writes that '[t]he true principle of individuation is mediation, generally supposing an original duality of orders of magnitude and the initial absence of interaction communication between them, followed by communication between orders of magnitude and stabilization.'

When an individual emerges in an intensive environment, it not only mediates previously non-communicative individuals, it can also enter into composition with 'other intensities [(other individuals)] to form another individual' (Deleuze & Guattari 1987: 253). The individual is composed of parts to which it acts as a whole, but it can simultaneously act as a part of another individual, that is, another process of individuation. For Simondon, psychic beings – individual humans – are always participants in the individuation of a collective.

For the question of de-proletarianization and the FabLabs, the upshot is that a milieu that is conducive to learning should be metastable. FabLabs are capable of

9 This poses a problem of origin, one which clearly motivated Simondon. He argues that pre-individual being precedes all individuation, that being started as a metastable system that had the capacity to 'fall out of phase with itself, that is, to resolve itself by dephasing itself' (Simondon 2009: 6). The potentials that existed in this primordial metastable system have since taken turns to actualize themselves in processes of individuation. This dephasing process is sequential because the potentials are incompatible, meaning that they cannot all be actualized at once. Even if that were true, it does not change the fact that every individuation subsequent to the first dephasing has had to contend with other individuals and individuations in its surroundings.

this metastability, but only if they enable a greater participation of their members beyond the use of its technological capacities. By giving their members the opportunity to approach the lab as a sociotechnical political problem, FabLabs could dramatically increase their de-proletarianizing potential. Unfortunately, as it stands, the willingness to open FabLabs to this kind of problematization has been limited.

Conclusion

In this chapter, I broached the question of (de)proletarianization and the FabLabs via the concept of resistance. First, I offered a different understanding of resistance as that which restricts intensive interactions. Drawing on the work of Foucault, Deleuze and Spinoza, I argued that resistance is both a variable that is internal to invention, as the capacity to resist, and a series strategies that prevent invention from occurring. It is this second kind of resistance that is the most relevant to the problem of proletarianization. Next, I discussed the strategies of resistance that inadvertently contribute to proletarianization, namely, intellectual property rights and what I call resistance by design. FabLabs have an important role to play in revealing and overcoming these strategies, which contributes to their overall de-proletarianizing potential.

However, when it comes to problematizing the FabLab itself as a political being, I noted that most FabLabs currently fall short. Not only do centralized decision making structures contradict their stated commitments to distributed power and horizontal hierarchies, they undermine their members' abilities to pose problems that are not only technological, but sociotechnical. In order to reach their full de-proletarianizing potential, FabLabs must become associated sociotechnical milieus. This requires that they be politically and technologically metastable.

Conclusion

The political struggles of the 21st century will be over the evolution and distribution of technological capacities. As it stands today, the vast majority of people living in Europe and North America, to say nothing of the rest of the world, finds itself underprepared and unable to participate in these struggles in a meaningful way. This current state of affairs can be attributed to a variety of reasons, not least the incredibly accelerated rate of technological change that distinguishes the past three centuries from the rest of human history. In a certain sense, one could say that we are victims of our own success as a species, considering the ecological impact of our expedited material transformation. However, such platitudes breed pessimism and complacency in the face of an open-ended situation where there is still plenty of room to manoeuvre.

Throughout this thesis, I have sought to clarify the nature of the problem that, following Stiegler, I have called proletarianization. Whereas Stiegler defines proletarianization as a loss of knowledge, I have argued that it is better understood as a limited ability to pose and solve political, social, and economic problems, new and old, mainly due to the increasingly technological conditions of these problems. Relying on ethnographic data compiled between the fall of 2015 and the summer of 2017, I have investigated the extent to which FabLabs, particularly European grassroots FabLabs, are able to address the problem of proletarianization. Underlying the whole of this research is a capacities-based pluralist ontology heavily inspired by Deleuze and the object-oriented ontologist Levi Bryant. Not only do I find this ontological framework convincing, I maintain that it is an important ideological tool against the constricting ontologies that reinforce proletarianization.

In this conclusion, I retrace the ground covered to distill the key findings of my research project. First, I return to the title of this thesis and offer a final analysis of the relationship between invention and resistance, and how it relates to the FabLabs and proletarianization. Concerned as I am that this thesis prove useful to the FabLab community that welcomed me with great affection, I then offer some practical proposals for existing and prospective FabLabs that share similar concerns for the predicaments of proletarianization.

I. Invention, Resistance, and Proletarianization

From the perspective of my ontological framework, invention and resistance both pertain to the relations between capacities, i.e., power relations. Invention is the activation of new capacities, resulting from the interactions between intensive individuals with compatible capacities to affect and to be affected. If, on the one hand, these new capacities reside in a technological object, then we are dealing with a case of *technological invention*. On the other hand, if the new capacities reside in a human being, then *learning* is the appropriate term for that kind of invention. The point is not to pin one form of invention against the other – there is no zero-sum game between technological invention and learning – but rather to understand the dynamics between the two in what I call a politics of invention.

Meanwhile, resistance is both a virtual capacity that gets expressed at varying degrees of intensity within a power relation, and a series of strategies that limit or restrict the formation of certain power relations. In the first instance, a being's capacity to resist is an internal variable of invention. To illustrate this claim, we could think of a carpenter selecting a particular wood for its resistance to expansion and contraction, or insect damage. The wood must have the capacities to be affected, such as the ability to be cut or engraved, but it should also be resistant enough that it can undergo those affects and others without falling apart. Far from being opposed to invention, the capacity to resist is part of its equation. That said, if the intensity with which a being expresses its capacity to resist crosses a certain threshold, it could break a power relation or bring about a new one altogether.

Strategies of resistance have a more complicated relationship with invention. By restricting and frustrating the emergence of certain power relations, one could argue that this kind of resistance is opposed to invention. More accurately, strategies of resistance oppose the actualization of specific inventions and combinations of capacities. In so doing, however, such strategies often involve inventing new beings that act as buffers or mediators, much like intellectual property rights are inventions that restrict the circulation of information. Thus, it is wrong to assume a binary opposition between invention and resistance, even when faced with obstructionist strategies of resistance.

For critical criminologists, I argue that it is crucial to move beyond the notion of resistance as that which subverts or opposes power. The conceptual distinction between a being's virtual capacity to resist and broader strategies of resistance provides new avenues of analysis and new ways of framing old problems. Often, criminologists are dealing with strategies of resistance that reinforce the status quo or exacerbate existing abuses of institutional control. Instead of calling any individual or collective action that challenges such power imbalances 'resistance,' I tried to provide a much more nuanced framework that treats resistance as a virtual capacity and intensive variable that has no inherent normative or subversive connotations.

While I agree with Hayward and Schuilenberg (2014) that there is an important link between resistance and invention, I cannot accept their thesis that 'to resist = to create.' Resistance is only creative to the extent that it functions as a variable of invention. Intensive fluctuations in the expression of a being's virtual capacity to resist will produce differences, but resistance alone is inadequate to the task of creation or invention. I believe that the conflation of resistance and invention is symptomatic not only of an under-theorization of resistance, but also a lack of thoughtful engagement with the concept of invention itself in criminological theory.

How, then, do invention, resistance, and their dynamics help us to understand or address the problem of proletarianization? For one, it should be apparent by now that the solution to proletarianization is neither simply more or less invention, nor more or less resistance. Proletarianization is not characterized by an absolute excess or lack of either invention or resistance, but rather by a particular distribution of invention and resistance across human and technological beings. Proletarianization is tied to an accelerated rate of technological invention, coupled with an unequal distribution of learning, specifically the learning of capacities that allow humans to relate to technological objects as more than users and consumers. As I argued in the last chapter, this poor distribution of invention is reinforced by strategies of resistance that stifle learning and the circulation of information, such as intellectual property rights and what I called resistance by design. Therefore, the problem lies not with too much technological invention, but with the legal, political, social, and economic conditions in which that invention takes place, and partly with the nature of the invented technological objects themselves.

Every technological object responds to a problem and the desire for a set of capacities that were not there before, or were not previously integrated into one being. At the same time, every technological object is also a new condition for the formulation of problems. The accelerated rate of technological invention in recent centuries has produced so many new conditions, and so rapidly, that it has left us all in a precarious predicament; we cannot formulate political, social, and economic problems befitting our contemporary circumstances. The profit-seeking motives of big tech manufacturers are exacerbating this problem, as are state efforts to use technology as a weapon against external and internal threats, not to mention the surveillance apparatuses being developed by both corporate and governmental actors. All of these factors serve to constrict the flow of the information that is the necessary precursor to learning and better problem formulation.

Faced with this difficult situation, one could be tempted to call for an immediate stop to further technological development until we are all brought up to speed on the current state of technology. However, not only is this practically impossible, it is also misguided in theory. Our response to proletarianization should not be to curb technological invention, nor to take the drastic steps taken by the fictional society in Samuel Butler's 1872 novel *Erewhon*. Butler imagines a human society similar to that of 19th century Europe save for two major distinctions: a complete lack of technological development beyond the levels of Roman antiquity, and the criminalization of illness rather than acts deemed harmful to others or society. Why Butler chose this second differentiator is certainly worthy of criminological attention, but it is the first that concerns us now.

At some point in the story, the protagonist discovers that Erewhon had once reached levels of technological advancement exceeding those of his native Victorian Britain, but had then collectively rejected and discarded all advanced technological artifacts. Driven by the prophetic *Book of Machines*, Erewhonians feared that they were in fact participating in the evolution of a new technological species that would eventually supersede and dominate humanity. Rather than birth their own masters, the people of Erewhon chose to halt the becoming of technology altogether.

Needless to say, there is no risk of such drastic measures coming to fruition in the 21st century, short of some apocalyptic event devastating our material infrastructure. The point, however, is that de-proletarianization should not be achieved by a levelling down of our technological capacities, which would only decrease our power of acting and cause a lot of sad affects. In other words, de-proletarianization should not be conceived of as the blanket elimination of the new technological conditions that have complicated our ability to pose and solve problems. Instead, de-proletarianization should be driven by a virtuous circle of joyful affects, learning and technological invention, so that the countless benefits of technology can be more evenly distributed across humanity.

As regards the relationship between de-proletarianization and resistance, there is no simple formula to follow. Clearly, de-proletarianization must involve the overcoming of specific strategies of resistance that constrict the flow of information and undermine learning. That said, it should also include the use of strategies of resistance that frustrate those forces that reinforce proletarianization, even if the latter are doing so inadvertently. Thus, invention and resistance fall on both sides of the (de-)proletarianization equation. With this in mind, I offer a final assessment of the FabLabs' de-proletarianizing potential.

II. FabLabs and De-proletarianization

To what extent are FabLabs sites of de-proletarianization? In my efforts to answer this central research question, I have had to clarify first what I understood by the terms proletarianization and de-proletarianization. If proletarianization is the process by which people *lose* the ability to pose and solve problems, then de-proletarianization is the process by which people *gain* the ability to pose and solve problems. Once again, it is important that we do not think of proletarianization and de-proletarianization as absolute conditions or end states, but rather as gradual tendencies that either decrease or increase our ability to problematize. Hence, de-proletarianization does not require that we reach a point where everyone possess a full grasp of technology and all the other conditions that structure our current political and economic problem. Such a point is unobtainable. De-proletarianization should instead be understood as a process that increases our capacity to problematize however modestly.

In the case of FabLabs, their de-proletarianizing potential lies in their ability to create milieus where people can learn and experiment with technology without having to pay costly tuition fees, meet strict entrance requirements for a university or college program, or invest heavily in their own workshops. By experimenting with technology, FabLab users cultivate a sensibility to technological objects, their capacities, and their composite nature. It is this sensibility that increases their ability to pose and respond to problems, identify the ways in which technological capacities are currently used to advance particular interests, and contingently resolve problems that are often hidden behind their resolutions.

Another key aspect of the FabLabs is their transdisciplinary character. Given that members are not segregated according to their areas of expertise, as is the case in most universities and workplaces, FabLabs are conducive to interactions between people of different skill-sets and expertise. In the words of one research participant, "the most important thing about the FabLabs is the interaction between different disciplines: engineering and science, tech and the creative world" (Interview 16). These interactions between people from various educational and professional backgrounds contradicts the extreme division of labour that sustains proletarianization.

The role of invention in the FabLabs is equally important when considering its de-proletarianizing potential. As previously stated, the amount of technological invention done in FabLabs pales in comparison to that done by the tech industry. The technological objects that do come out of FabLabs tend not to have much of an impact on the societies in which they are made, meaning that they rarely factor as new conditions to collective problems. Nevertheless, the power of these inventions is that they are shared as digital information (CAD files, or other online documentation) that is hyper-mobile, non-rivalrous, and highly malleable. Thus, FabLabs create a virtuous circle between technological invention and learning, which, thanks to the massive reach of the Internet, is not bound by the limitations of temporal and geographic proximity. The more FabLabs there are in the network, the greater the circle and its impact.

Regarding resistance, FabLabs play a crucial role in exposing the many strategies of resistance that contribute to proletarianization. Although they have decided to remain officially agnostic on the question of intellectual property rights, in practice, labs have managed to foster a culture of sharing which translates into most design files being licensed as free or open source (if at all). This reduces the resistance faced by those who want to learn and experiment with those designs or techniques.

Additionally, FabLab members tend to use free and open source software and hardware to create their objects, which are not only more accessible and affordable (for the most part), but also more conducive to learning. For example, the open source microcontrollers produced by Arduino, which are extremely popular with the maker movement, are designed to be learner friendly and there is an abundance of instructional material available online, much of it free, on how to use, program, and alter Arduino products. By building off of free and open source technology, FabLabs are making objects that are open and transparent if not all the way down to the atomic level, then certainly further down than most proprietary software and hardware.

Beyond intellectual property rights, through events like 'Hack-a-Thing' gatherings or Repair Cafés*,* FabLabs draw attention to the ways in which the devices and appliances developed by profit-seeking manufacturers have been designed to frustrate our access to their internal mechanisms and their parts. This resistance by design is certainly important when we consider the ecological effects of planned obsolescence, e-waste, as well as the over-consumption and over-production of technological devices, but it is equally important to the problem of proletarianization. Resistance by design reinforces the perception that a technological object is a totalizing whole, unchangeable and, ultimately, too complicated or sophisticated for its simple owner to comprehend. Of course, we know that there are a lot of parts working together within our devices, but we are not afforded the opportunity to problematize their arrangement within the object, or consider how those parts might combine with others to form different wholes with different capacities. Out of sight, out of mind.

Politically, FabLabs espouse a commitment to inclusivity, de-centralized organizational structures, and horizontal hierarchies. The actual application of these principles is patchy, and varies significantly from lab to lab. Nearly all the labs I visited and researched, with the notable exception of FabLab Budapest, had set blocks of ‘Open Lab’ time when non-members are able to use the facilities and the equipment free of charge, although many labs would ask to be reimbursed for the materials used (printer filament or cardboard). Institutionally hosted labs, such as the FacLab at the Université de Cergy-Pontoise North of Paris, can afford to offer access and materials for free, asking people to make non-financial contributions to the lab instead, be it in the form of helping to clean, cook, organize workshops, or document their work. Understandably, this is a difficult system for financially limited grassroots labs to emulate.

FabLabs grant their users the freedom to choose what to do while they are in the lab. Outside of directed workshops and other structured events, people are free to do what they want, within the limits set by the labs capacities and consideration for the safety of themselves and others. Contrary to commercial manufacturers, there is no clear separation of the conception and execution of tasks in a FabLab, no employer/employee relations where one sells their obedience for a wage. By and large, people are free to select their projects, which is to say that they are free to formulate their own problems. People can help each other on projects if they so choose, but there is no contractual obligation or financial incentive that pushes them to do so. This freedom to formulate one’s own problems and solutions is essential to de-proletarianization.

Where grassroots FabLabs tend to deviate from their stated political principles is in the management of the labs themselves. Of the labs I researched in depth, only the Petit FabLab de Paris had an inclusive management structure that allowed members to participate in the decision making process on everything from ordering new equipment, to what public events the lab should have that month. The rest operate along the lines of small businesses with one or two founding partners reserving the rights to make all managerial decisions. While these arrangements are justified on the basis that founders are financially liable, they undermine a lab’s de-proletarianizing potential significantly by denying its members the opportunity to problematize the lab, its internal power relations as well as those with external actors.

The penchant for centralized managerial structures is emblematic of a deeper political agnosticism that is prevalent among FabLab members, the majority of whom are design students and creative professionals. The ethnographic data, including my own, point to a clear precedence of technology over politics for these users. So long as they are accorded their autonomy in the lab, they seem disinterested in the lab as a political entity. As a consequence, the political evolution of a FabLab normally does not feature as a topic of discussion or concern for its users and organizational structures that are antithetical to their stated principles are accepted as pragmatic or benign.

However, simply pointing out this inconsistency is insufficient. For the purposes of determining a FabLab's de-proletarianizing potential, a centralized organization structure is not important because it is inconsistent, but because it prevents the lab from becoming what Stiegler (2010: 51) calls a 'sociotechnical associated milieu.' If the ultimate goal of de-proletarianization is to give people the capacities to problematize and affect the political and technological conditions under which they learn, live, and work, then those capacities must be cultivated within the labs themselves. A lab should be a metastable milieu that has the capacity to be affected by as many of its parts as possible. It should be perceived by its members not just as a space of technological invention and learning, but as a being engaged in a process of becoming that is sociotechnical. More importantly, members should see themselves as conditions in the political problems that the lab engenders, conditions that are themselves in processes of becoming and that are able to create new conditions through their capacities.

Another major limiting factor on the FabLab network's de-proletarianizing potential is its relatively homogenous demographic composition. Given the significant number of labs that exist in the Global South, it would be unfair to say that FabLabs exacerbate any global inequalities in access to technology. In fact, many of those labs are working to provide basic technological infrastructures where none exist. That said, when we consider the demographics of those who frequent FabLabs in Europe, there is a clear underrepresentation of people who are non-white or non-male. Furthermore, European FabLabs have failed so far to attract enough people who are not already working or studying in fields that are technologically oriented, such as design or engineering. This issue could be dismissed on the grounds that it is normal for early-adopters to be tech-savvy and that it is too soon to judge FabLabs too harshly on this point. Nevertheless, it is still a serious limitation on a

FabLab’s de-proletarianizing potential as it narrows the range of perspectives that participate in the processes of problem formulation and problem solving.

In sum, the extent to which a FabLab is a site of de-proletarianization varies notably from lab to lab. The main variable in assessing a lab’s de-proletarianizing potential is how many ways it can be affected by the capacities to affect of its members. To see the lab itself as a problem, a being in becoming, is essential to the cultivation of those capacities that are needed in the process of de-proletarianization; essential to learning how to de-proletarianize. The invention that occurs in a lab, be it learning or technological invention, ought to affect not only those people and things immediately involved in the inventive process, but also the lab and its other users, the FabLab network, and the wider community in which the lab resides. In so doing, the FabLab becomes a veritable force of de-proletarianization where people engage with problems that are greater than themselves and their immediate desires to make customized items that the market cannot provide.

III. Practical Proposals for De-Proletarianization

It is my hope that this thesis proves useful not just by offering the uninitiated an admittedly unconventional primer on the FabLabs and their role as agents of de-proletarianization, but also to the FabLabs themselves and their members, particularly those who regard what I call proletarianization as a problematic process that ought to be reversed. To that end, I have some practical proposals for de-proletarianization, i.e., strategies and ideas that I believe would increase a lab's de-proletarianizing potential. Needless to say, there is nothing I could teach a seasoned maker when it comes to the lab's technological capacities and specific pieces of equipment. Still, I hold that the time I have spent researching the FabLabs gives me some license to make the following suggestions.

First, FabLabs should ensure that all of their software and hardware is learner friendly, which is not the same as beginner or user friendly although, ideally, it would be all those things. A technological object is learner friendly when, in addition to exhibiting its main functions (printing or cutting for example), it makes it easier for people to understand how it works and how it might be altered. In short, these should be what Simondon calls 'open objects,' as elaborated in Chapter 4. All too often, a commitment to user friendliness is used as a justification for shielding off an object's internal mechanisms from its users by way of designed resistance strategies.

While free and open source software and hardware *tend* to be more learner friendly than their proprietary counterparts, learner friendly and free and open source are not synonymous. Nor should FabLabs feel obliged to maintain a kind of free and open source purity when it comes to choosing their technological equipment. Proprietary equipment ought to be used when there is no good free and open source alternative. That said, every effort should be made to provide as much information on proprietary equipment as possible, well beyond what is usually found in the manufacturer's user manual, which leads me to my second recommendation.

FabLabs should draw more attention to the strategies of resistance by design and planned obsolescence that exist in proprietary hardware. This starts with the proprietary equipment in the lab itself, highlighting to members the built in restrictions of the machines they are working with and finding ways to circumvent them. Better still, events like Hack-a-Thing or Repair cafés are crucial to spreading this awareness. Such events are currently underutilized as a way to engage a wider low-tech community and give the FabLabs greater exposure. Part of the reason why people do not go to a FabLab, if they have even heard of one, is that they do not know what they would do there. Like me, they would feel intimidated at the prospect of entering a new world of digital fabrication with limited technological ability, a world that seems far detached from their lived reality. Hack-a-Thing and Repair cafés can help people overcome those reservations by providing some structure for newcomers and by relating the capacities of the lab directly to the objects in their lives, even if those objects might have 'expired' some time ago and is now regarded as little more than junk by its owners.

My third suggestion, which is closely related to the second, is that FabLabs play a more active role in the Right to Repair movement. It could be as simple as encouraging their members to contribute to the online databases of repair manuals, such as iFixit and Repair.org, but it could also involve public opinion campaigns to raise awareness of this issue. The Right to Repair campaign is an ideal political issue that would garner a great deal of support among current FabLab members, as it is not too politically charged. Although I would like to see the FabLabs get involved with more radical political projects, I am mindful of the fact that the majority of current FabLab users would be turned off if all FabLabs started to explicitly advocate the end of capitalism and private property. It should be up to each individual lab to choose the political projects they want to engage in or not, but I believe that the Right to Repair would be an easy sell in most labs.

It also matters how FabLabs make decisions, political or otherwise. Hence, my fourth proposal is that FabLabs strive to make their decision making processes as democratic and inclusive as possible. Exactly what those processes are in practice should be left up to each lab and its members, but it is clear, based on my research and that of others, that too many FabLabs currently have insufficiently democratic decision making processes. Without greater democratization, the FabLabs cannot live up to their de-proletarianizing potential. Moreover, the concentration of decision making power in the hands of a few lab executives makes the FabLabs more susceptible to external disruptions.

It has been a little over a decade since the FabLab phenomenon took hold in Europe, independently of the Center for Bits and Atoms at MIT. Within that time period, the number of institutionally hosted and grassroots labs has continued to grow at an astounding rate. As their ranks continue to grow, so too does the attention that FabLabs receive from more established institutions, such as the media, governments, corporations, and, naturally, academia. On the whole, this attention is positive and a sign that FabLabs and the maker movement are gaining traction, but it also carries with it the injection of new interests and agendas that can fundamentally alter the way FabLabs function.[10] I worry that the lack of democratic processes could result in the rapid take over of FabLabs by outside institutions with minimal member consultation or resistance. This is especially true for labs that are struggling financially, of which there are many.

Once again, I do not mean to argue that grassroots FabLabs should not enter into financial or political partnerships with external institutions. I am simply saying that the decisions to do so should be made democratically. Whether or not to form these partnerships and, if so, on what conditions, are precisely the kind of problems that people should be involved in to practice de-proletarianization. It is an added bonus that democratic decision making processes are far more in line with the organizational principles of a distributed network that underpin the FabLab project.

The fifth and final proposal is to pay more attention the state of the FabLab network, be it at a municipal, regional, national, or international scale. Just as an individual FabLab ought to be problematized by its members, so too should the networks between labs be sites of problematization. There is a danger that networks are assumed to exist simply by virtue of the fact that multiple makerspaces share the name 'FabLab,' when in fact 'building a network is not easy, nor automatic' (Interview 16). In the absence of concerted network building efforts from FabLabs themselves, it is easier for certain actors to claim that they are 'speaking on behalf of' or 'representing' a network of FabLabs that either does not exist or did not accord that actor any representational legitimacy. I am thinking specifically of the Fab Foundation which many of my research participants spoke off with great skepticism

10 One research participant told me that he already sees the term 'maker movement' becoming a feel-good buzzword for politicians to use without any real thought or consideration, much like he felt the word 'sustainability' has been exploited to advance policy proposals that have little to do with ecology (Interview 17).

and concern that its leaders had too much power in shaping the public narrative around FabLabs. That concern should be translated into actions that build stronger, more democratic networks that can be mobilized on larger scale projects and campaigns.[11]

IV. Conclusions and Future Research

The overarching goal of this thesis was to establish the dynamics between FabLabs and the problem of proletarianization. I do so through the lens of a capacities-based ontological framework and a cartographic method, both of which are heavily inspired by the thought of Gilles Deleuze and, to a lesser extent, Levi Bryant. If those thinkers inspired the frame of this work, it is to Bernard Stiegler and Gilbert Simondon that I owe the problem of proletarianization. In all cases, I have tried to make new connections and bring forth ideas with different capacities. Invention and resistance have been my preferred conceptual tools to open up the question of proletarianization and give it a renewed purpose, but, undoubtedly, there are other concepts that can generate equally important contributions to this debate. Further research should be undertaken to develop new concepts to better grasp the problem of proletarianization.

By focusing on the FabLabs as the empirical basis for this research, my aim was to ground proletarianization and its opposite – de-proletarianization – in something concrete and affirmative. All too often, academics of a critical persuasion content themselves with pointing to problems without consideration for how we might respond to them. Not only does this contribute to a sense of pessimism and impotence that at times can be suffocating, it also misses the point that many of a problem's underlying conditions only emerge as we try to address it.

Based on my investigation, I have determined that the FabLabs are, at best, a partial response to the problem of proletarianization. Their de-proletarianizing potential lies in their emphasis on the increasingly technological conditions of the many collective problems that we are currently dealing with as societies and as a

11 The 'Fab City' project, led by Tomás Díez in Barcelona, is a good example of this kind of networked collaboration. The project aims to develop urban digital fabrication infrastructures that, over time, could relocalize a sizeable amount of material production in cities. Instead of importing products and exporting trash, a Fab city would mostly import and export data, in the form of CAD files, and institute a local circular economy that recycled as many material resources as possible (Díez 2016). The project is, to say the least, extremely ambitious, but it raises a lot of important questions about the future economic roles of FabLabs.

species. The virtuous cycle that they strive to create between technological invention and learning is necessary to de-proletarianization, but insufficient without the democratization of the decision making processes in most labs. Only then would the FabLabs allow people to problematize the technological and the political together, the true task of de-proletarianization. Given the limitations of the FabLabs, future research projects should look for other actors and practices that respond to the problem of proletarianization and reveal more of its conditions so that we might change them.

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Appendix A. List of Interviews

Interview 1: 6 November 2015, Stadslab Rotterdam, Peter

Interview 2: 8 March 2016, Fabulous St Pauli (Hamburg), Astrid

Interview 3: 11April 2016, Fabulous St Pauli (Hamburg), Niels

Interview 4: 9 May 2016, Fabulous St Pauli (Hamburg), Axel

Interview 5: 17 June 2016, Fabulous St Pauli (Hamburg), Christopher

Interview 6: 24 June 2016, Extramuros (Paris), Yohan

Interview 7: 13 July 2016, Fabulous St Pauli (Hamburg), Niels

Interview 8: 2 November 2016, le Petit FabLab de Paris, Laurent

Interview 9: 5 November 2016, le Petit FabLab de Paris, Étienne

Interview 10: 9 November 2016, WoMa (Paris), Alex

Interview 11: 10 November 2016, FacLab (Paris), Antonin

Interview 12: 12 November 2016, le Petit FabLab de Paris, Constance

Interview 13: 23 January 2017, le Petit FabLab de Paris, Hadar

Interview 14: 25 January 2016, FacLab (Paris), Adel

Interview 15: 28 January 2017, le Petit FabLab de Paris, Simon

Interview 16: 31 January 2016, le Petit FabLab de Paris, Laurent

Interview 17: 25 February 2017, FabLab Budapest, David

Interview 18: 18 March 2017, FabLab Budapest, Garth

Interview 19: 15 April 2017, FabLab Budapest, Peter

Interview 20: 30 July 2017, FabLab Budapest, David

Appendix B. Summary of Findings

Research Aims

The purpose of this research project is to investigate the extent to which Fabrication Laboratories, or FabLabs, are sites of de-proletarianization. Marxists have historically defined proletarianization as the expansion of a socio-economic class that must sell its labour to the owners of the means of production. In this thesis, I build on the work of contemporary philosopher Bernard Stiegler to develop a new understanding of proletarianization as a process that weakens our individual and collective abilities to formulate and respond to problems, be they social, economic or political.

I argue that proletarianization is largely driven by an accelerated rate of technological change, coupled with an unequal distribution of the capacities necessary to understand and participate in that change beyond the roles of users and consumers. Whether it is global warming, national security, or crime control, the problems that we face collectively are increasingly shaped by technological conditions that the majority of people are unable to shape or influence. Technology is not *the* problem, but it is a crucial part of most problems, as well as a major part of the responses to those problems. Proletarianization weakens and limits the connections between humans and technologies, making it difficult for people to better grasp important issues and develop different responses to them. De-proletarianization, therefore, involves cultivating more human capacities to interact with technology, not only as users of technology but as collaborators in its evolution.

FabLabs are digital fabrication workshops committed to democratizing access to technology. They are a part of a wider movement of makers, people who create their own electronics and other objects. The maker movement shares a lot of similarities with the free and open source software movement that started in the 1980s. Both movements have a culture of sharing and collaboration that has led to the production of hardware and software that people can not only use, but also study, modify and copy. Together, these movements challenge the logic of restrictive intellectual property rights and shed light on the ways in which tech manufacturers try to make their products as opaque as possible to protect their bottom lines.

By enabling people to make their own technological objects, FabLabs appear to have an important role to play in reversing proletarianization. This thesis examines this hypothesis using ethnographic data collected from FabLabs in Hamburg, Paris, and Budapest over a period of 20 months between the fall of 2015 and the summer of 2017.

Key Findings

Based on my ethnographic research and the findings of other relevant academic studies, I argue that FabLabs have a significant de-proletarianizing potential that is currently underdeveloped and poorly distributed. FabLabs provide a space for people to learn and experiment with technology with very few restrictions (no tuition fees or entrance requirements, for example). In a lab, people are free to choose what they do, when they want, and with whom they want. There are no employee/employer relations, nor are there any fixed teacher/student relations. People are encouraged to assist each other, to collaborate, and share their knowledge with others, either within the lab itself or online in the form of video tutorials or digital design files. These practices are de-proletarianizing because they push people to formulate their own problems and problematize technology.

Despite this potential, the actual de-proletarianizing effect of the FabLabs is currently limited. The majority of FabLab users in Europe tend to have an educational or professional background in computer science, engineering, or design, and they also tend to be white males. As a consequence, FabLabs are mostly catering to the interests of a relatively narrow section of their surrounding populations, a demographic that is already technologically savvy. Moreover, most FabLabs have centralized decision making processes that revolve around a closed group of founding members. While these arrangements are justified on the basis that founders have invested the most financially, they undermine a lab's de-proletarianizing potential significantly by denying its average members the opportunity to problematize the lab, its internal power relations as well as those with external actors.

If the ultimate goal of de-proletarianization is to give people the capacities to problematize and affect the political and technological conditions under which they learn, live, and work, then those capacities must be cultivated within the labs themselves. A lab should be perceived by all its members not just as a space of technological invention and learning, but as an evolving entity that is as political as it is technological. Most importantly, members should see themselves as active participants in that evolution.

Appendix C. Zusammenfassung der Forschungsergebnisse

Forschungsziele

Das Ziel dieses Forschungsprojektes ist es zu untersuchen, inwieweit Fabrikationslabore, sogenannte FabLabs, De-Proletarisierungs-Standorte sind. Historisch haben Marxisten Proletarisierung als die Expansion sozial-ökonomischer Klassen bezeichnet, die ihre Arbeitskraft an die Inhaber von Produktionsmitteln verkaufen müssen. In dieser Dissertation stütze ich mich auf die Arbeit des zeitgenössischen Philosophen Bernard Stiegler, um ein neues Verständnis von Proletarisierung zu entwickeln. Proletarisierung verstehe ich hier als Prozess, der unsere individuellen und kollektiven Fähigkeiten schwächt um Probleme sozialer, ökonomischer oder politischer Natur zu formulieren und auf diese Antworten zu finden.

Ich argumentiere, dass Proletarisierung vor allem durch einen beschleunigten Technologiewandel angetrieben wird, der einhergeht mit einer ungleichen Verteilung von Fähigkeiten, diesen Wandel zu verstehen, und sich an diesem außerhalb der Nutzer- und Konsumentenrollen zu beteiligen. Ob es um globale Erderwärmung, nationale Sicherheit oder Kriminalitätskontrolle geht: Die Probleme mit denen wir als Kollektiv konfrontiert sind, werden stetig stärker von technologischen Bedingungen geprägt, welche die meisten Menschen weder gestalten noch beeinflussen können. Technologie ist nicht *das* Problem, jedoch ist Technologie ein wesentlicher Teil von fast allen Problemen und den Antworten auf diese Probleme. Proletarisierung schwächt und limitiert die Verbindung zwischen Menschen und Technologien und macht es Personen schwer, wichtige Themen besser zu erfassen und verschiedene Antworten darauf zu entwickeln. Auf Grund dessen geht es bei De-Proletarisierung darum, humanere Fähigkeiten zu kultivieren, die es ermöglichen, nicht nur als Nutzer mit Technologie zu interagieren, sondern auch an der Entwicklung der Technologie teilzunehmen.

FabLabs sind digitale Fabrikations-Workshops, die es sich zur Aufgabe gemacht haben, den Zugang zu Technologie zu demokratisieren. Sie sind Teil einer größeren Bewegung von Herstellern („Maker"), die ihre eigene Elektronik und andere Dinge kreieren. Das „Maker-Movement" hat viele Gemeinsamkeiten mit der in den 1980ern gestarteten Bewegung zu frei zugänglicher „Open-Source-Software". Beide Bewegungen zeichnen sich durch eine Kultur des Teilens und der Zusammenarbeit aus, die zu der Produktion von Hardware und Software geführt hat, welche Menschen nicht nur nutzen, sondern studieren, verändern und kopieren können. Zusammen fordern diese Bewegungen die Logik von restriktiven Eigentümerrechten heraus und machen darauf aufmerksam, auf welche Art und Weise Produzenten ihre Produkte so hermetisch wie möglich gestalten, um ihre Profite zu beschützen.

Indem die FabLabs Menschen ermöglichen, ihre eigenen technologischen Dinge zu fabrizieren, scheinen sie eine wichtige Rolle in der Umkehrung von Proletarisierung zu spielen. Diese Hypothese wird in der vorliegenden Arbeit anhand von ethnographischem Material aus FabLabs in Hamburg, Paris und Budapest geprüft, welches in einem Zeitraum von zwanzig Monaten zwischen Herbst 2015 und Sommer 2017 gesammelt wurde.

Zentrale Ergebnisse

Basierend auf meiner ethnographischen Forschung und anderen relevanten akademischen Studien argumentiere ich, dass FabLabs ein signifikantes Potential zur De-Proletarisierung aufweisen, welches jedoch derzeit unterentwickelt und nicht sehr verbreitet ist. FabLabs stellen einen Raum für Personen zur Verfügung, in dem diese ohne besondere Einschränkungen (z.B. gibt es keine Unterrichtsgebühren oder Teilnahmebedingungen) mit Technologie lernen und experimentieren können. In einem Lab können die Menschen frei entscheiden, was sie mit wem und wann tun wollen. Dort gibt es weder Arbeitnehmer- und Arbeitgeberverhältnisse noch feste Lehrer- und Schüler Konstellationen. Die Menschen werden ermutigt, einander zu unterstützen, zusammen zu arbeiten und ihr Wissen untereinander zu teilen. Entweder innerhalb des FabLabs selbst oder in Form von online Video-Tutorials oder Fabrikationsanleitungen in digitalen Ordnern. Diese Praktiken sind de-proletarisierend, weil sie Menschen dazu antreiben, ihre eigenen Probleme zu formulieren und Technologie zu problematisieren.

Trotz dieses Potentials ist der eigentliche De-Proletarisierungseffekt der FabLabs gegenwärtig limitiert. Die Mehrheit der FabLab-Nutzer in Europa tendieren dazu, einen Bildungsabschluss und beruflichen Hintergrund in Computerwissenschaften, Ingenieurswissenschaften oder Design zu haben und sind meistens weiße Männer. Folglich bedienen FabLabs die Interessen eines relativ begrenzten Teils ihrer unmittelbaren und demographisch schon Technologie affinen Nachbarschaft. Darüber hinaus haben die meisten FabLabs einen zentralisierten Entscheidungsprozess, der sich um eine kleine geschlossene Gruppe von Gründungsmitgliedern dreht. Während diese Arrangements dadurch gerechtfertigt sind, dass die Gründungsmitglieder am meisten finanziell investiert haben, untergraben sie dadurch signifikant das De-Proletarisierungs-Potential des Labs. Dies geschieht vor allem durch die Verweigerung der Möglichkeit für Durchschnittsmitglieder, das Lab selbst und die dortigen internen und externen Machtverhältnisse zu problematisieren.

Wenn das ultimative Ziel von De-Proletarisierung ist, den Menschen die Fähigkeiten zu geben, die politischen und technologischen Bedingungen unter denen sie lernen, leben und arbeiten zu problematisieren und zu beeinflussen, dann müssen diese Fähigkeiten innerhalb der Labs kultiviert werden. Ein Lab sollte von allen seinen Mitgliedern nicht nur als Ort technologischer Erfindung und des Lernens wahrgenommen werden, sondern als eine sich sowohl politisch als auch technologisch entwickelnde Einheit. Am wichtigsten jedoch ist, dass sich die Mitglieder selbst als aktive Teilnehmer in dieser Entwicklung sehen sollten.

Declaration of Authorship

The research embodied in this thesis is my own work and has not previously been submitted for a degree at any other universities. I have not used commercial doctoral advisory services. I have not used any sources or aids other than those listed.

-Stefano Mazzilli-Daechsel