

JUST LABOR TRANSITIONS: WORKFORCE POLICIES IN TIMES OF TECHNOLOGICAL
CHANGE

by

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ABSTRACT

The narratives on technological change and the emergence of the "fourth industrial revolution" (4IR) play a significant role in defining what has happened and is happening in the labor market. Those narratives, mainly based in developed countries, have served as a turning point for policy development, especially regarding the design and implementation of educational and labor strategies as policy instruments to cope with the challenges of inequality and its labor-related causes. However, the specificities of past labor and educational policies play a crucial role in understanding the possible effects of large-scale transformations related to technological change. In this research, I develop a theoretical model connecting the experience of the third industrial revolution, the current assumptions for the future of work agenda, the forecast regarding the possible impacts of the fourth industrial revolutions, and the areas for policy intervention. I use the model to craft a case study, where I present evidence regarding the evolution of the Chilean labor market between 1990 and 2020, following the evolution of job polarization, occupational composition, workforce educational attainment, economic complexity, and the technological ecosystem. I compared those elements with the stylized facts and assumptions of the narratives of technological change. I argue that the differences in the process of workforce adaptation (timing and material conditions) can shed light on the assumptions of the "future of work" agendas, especially by tackling how different conditions could reach different results and craft substantively different base scenarios for policy design and implementation of human capital-based interventions as the ones suggested by international organizations and forums. In the concluding chapter, I summarize the findings and comment on how to address the design of just labor transitions.

DEDICATION

This dissertation is a product of a large set of decisions and actions that were supported by my family. To them, my lifelong recognition and gratitude for cherishing, cheering, nurturing, and guiding me during the process of becoming a scholar.

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CHAPTER 1

PRESENTATION

The future of work has emerged as a relevant matter for public discussion. Several International Organizations, such as the International Labor Organization (2020), the United Nations Industrial Development Organization (2019), the United Nations Development Programme (2019), the Organization for Economic Cooperation and Development (2019), and other agencies and interest groups like the World Bank (2019, 2020b) and the World Economic Forum (2020b; 2018) are pushing agendas regarding the future of work. With different approaches, the primary concern for those international organizations is how to understand technological change effects on employment and social welfare and then promote policy alternatives or public-private arrangements to cope with the challenges derived from the inclusion of disruptive technological advances in the production process.

The concerns about the impact of new technologies on national economies and labor markets appear to be justified. The last wave of technological change represented by workplace computerization and large-scale adoption of Information and Communication Technologies (ICTs) have produced several consequences for labor markets and social inequality (Atkinson, 2015; Neal & Rosen, 2000). Both processes dramatically changed the relationship between educational attainment and skill valuation in the labor market (Katz & Autor, 1999), increasing the heterogeneity of educational returns of higher education and decreasing or compressing the wages for low-educated people (Acemoglu & Autor, 2011). Since access to higher education depends on the specific policy environment of each country, the uneven opportunities for tertiary education enrollment in diverse countries have contributed to the increase in inequality across societies (Schofer & Meyer, 2005; Triventi, 2013; X. Wang, 2020).

However, the current narratives of the fourth industrial revolution (4IR) and the digital economy are not focused on general skills represented by formal education but on specific digital-related skill sets (World Economic Forum, 2020b; 2018). While in the knowledge economy, a specialized workforce was produced through formal education and the continuous return to educational institutions (Kazamaki Ottersen, 2004; Wilton, 2011), the digital economy appears to fragment the knowledge and skills into specific forms of human capital, disentangling skill acquisition from formal education signaled as open-access learning (Benlamri & Klett, 2015). Whichever would be the institutional solution to the perceived skill shortages produced by the up-taking of digital technologies, individuals face a tension between the longstanding discourses of the knowledge economy and the lifelong education solution to employability (Novoa, 2007; Siivonen & Isopahkala-Bouret, 2016) and the atomized view of skills and tasks carried by the narratives of the "future of work" agendas (Delfanti & Frey, 2020; Holford, 2019).

The tension between the imaginaries of knowledge and digital economies regarding the role and relevance of human capital is a problem, not only for individuals for their educational attainment decision-making but also for policymakers that look for alternative pathways to smooth workers' adaptation to new labor market demand conditions. This research aims to problematize this tension using the case of Chile, a high-income country in South America, to show how the institutional setting and national economies' dynamics can play a role in the effectiveness of human capital interventions as a policy tool to engage the problem of technological change and its effects on labor market structure and operation. Specifically, this research seeks to encompass different sources of evidence to depict the process of workforce adaptation during the global process of technological change to inform policymaking regarding the development of the "future of work agendas."

This dissertation contributes to the literature on administration and public policy in diverse ways. First, the research is focused on a less developed country that has presented contradictory evidence of polarization in the last thirty years (Didier, 2021a; Gasparini et al., 2021; Martins-Neto et al., 2021) with a distinctive pattern of changes in the labor market structure. Second, this research allows problematizing the issue of technological change, skill-upgrading, and job polarization in an imperfect labor market characterized by an atomistic view of labor relations, low power of unions, the dominance of low-skilled workforce demand, and low effectiveness of active labor market policies (Didier, 2022; Larrañaga et al., 2011; J. Rodríguez et al., 2021; Schneider & Soskice, 2009). Third, the research provides evidence regarding the absence of occupational upgrading in the labor market during workforce skill-upgrading, addressing the educational policy background on occupational structure change. Fourth, the evidence provided by the research could enhance the possibility of policy learning and diffusion across Latin American countries, creating a similar point of comparison to address labor and educational policies to cope with the issues brought by the "future of work" agenda. Finally, the results can provide some elements in the discussion on higher education expansion in the continent, especially in the dilemmas between quality and quantity (Chiroleu & Marquina, 2017; Ferreyra et al., 2017) and the problems derived from educational credentialism (Didier, 2021b) and the effectiveness of human capital accumulation as a vehicle for social mobility.

I. A Theoretical Proposal: Just Labor Transitions

I frame this research using the concept of just labor transitions to understand the alternatives for policymaking in the context of technological change provided by the 4IR. The main idea behind the perspective offered in this research is that regardless of the balance between social and public values and its idiosyncratic institutional

arrangements, the government can and shall play a relevant role in defining the adaptation of national economies to the re-structuring of production structures. I support this normative approach in three considerations encompassing socio-economic arguments surrounding the debate, summarized in plausibility, situational and capabilities-oriented principles.

The plausibility principle is grounded in the development of the historical experience of industrialized countries regarding the 3IR. Specifically, it focuses on the link between economic inequality and its precursors in technological change. During the prior wave of technological change, computers and ICTs inclusion in the production process led to a change in the substitution-complementary relationship between labor and capital, accelerating the displacement of semi-skilled and un-skilled workers to low-quality jobs (explained in-depth in chapters 2 and 3). Those antecedents of redefinition in the employment matrix and job quality are assumed as a possible pathway of workforce response or adaptation strategy during the 4IR. In that sense, there is an assumption that past behavior predicts -at some level- future behavior. This line of thought reasonably explains international organizations' reactions to the possible scenarios of technological change and their proposals regarding how to address the emergent issues of the 4IR.

One way to address the issue of the changing factor relationship between labor and capital is the WEF's (2018) agenda of reskilling revolution. In a broad sense, that agenda represents the articulation between two poles/ideas: (a) there is an ongoing transformation in the production process given a set of disruptive technologies, and (b) getting the economic benefits of technological change to depend on how economic systems deal with the skill-shortages. Whether there is an implicit or explicit policy addressing the changes and challenges of the 4IR, technology is transforming the labor

realm by changing the task structure of jobs and allowing to advance in the complete substitution of labor in some spaces of the production process.

Career or occupational transitions are promoted as the natural response to automation and disappearance, allowing individuals to move forward by switching to less-intense-technological occupations or advancing through skill acquisition to more contingent demand for digital-dependent jobs. The trend points to task redefinition by each occupation, either by partial or complete substitution for the semi and unskilled workforce or by a change in the complementarity for more complex occupations. That redefinition is accompanied by the idea of a transition between “jobs families” proposed as one of the components of the reskilling revolution (World Economic Forum, 2021).

How can those transitions take place in diverse settings? Moreover, how can the government promote fairness or justice during those transitions? Prior evidence suggests that institutional factors like universal policies for post-secondary education (i.e., higher education and active labor market policies) allowed some countries to avoid the job market polarization associated with the 3IR. Although the expansion of tertiary education cannot be established as a consistent or deliberate policy response to technological change, the literature has signaled differential effects on labor-driven technological change (explained in-depth in chapter 3). For example, the differences between countries with unequal access to higher education (i.e., U.S. and U.K.) compared to countries with more egalitarian access (i.e., Germany and France) leads to thinking that targeted policies could generate better outcomes for the whole society compared to a *laissez-faire* alternative. Thus, it is plausible for governments to develop interventions to smooth the transition between the labor markets’ current structure and the projected scenario labeled as “the future of jobs.” Following that rationale, envisioning justice and equity as values inspiring the transformation of the

labor realm will lead to the balance of the elements of economic efficiency and social welfare.

However, the policy instruments considered facilitators of career or occupational transitions have been scrutinized. That revision has been related to debates on “equal opportunities – unequal outcomes” (Roemer & Trannoy, 2015) and the extra-institutional elements that have sustained arbitrary labor market behavior across time (i.e., discrimination against minorities and disadvantaged groups, ageism, and gender gaps) (Rafferty, 2012; Stypinska & Turek, 2017; United Nations, 2022c). Therefore, the second principle will summarize the situational dimension of the technological adaptation process, considering how past policies have interacted with the differential treatment of groups by the labor and educational market and how that interaction can shape the current policy response.

A “*just labor transitions*” approach for policymaking implies developing interventions to make available the educational supply for workers’ skill upgrading and considering how the historical operation of the labor market would condition the effectiveness of those interventions. In this sense, two concerns should be included in the analysis: entry conditions or eligibility for targeted policies regardless of the social background of the citizens (Frederickson, 1980; Jreisat, 2011) and the envisioned effects of those policies. Since ex-ante characteristics could lead to a different outcome for policy implementation, policymakers should consider in a balanced matter not only “what” is a matter of intervention but also “who” is the subject of that intervention.

The capabilities approach inspires the third principle entangled in the concept of just labor transitions (Nussbaum & Sen, 1993). The capabilities approach allows the framing of policymaking not only the problem of availability of interventions encouraging or facilitating to acquire of the skills that the labor market will demand but to include to which degree those policies enable people to reach their valued sets

of “beings and doings” that motivate their behavior. In a broader sense, policy interventions related to skills upgrading will form part of the resources available in the environment, but the use or choice of some of those resources depends on individuals’ idiosyncrasy. That will lead to consideration regarding the definition of the population subject to human-capital-based interventions, and especially to the aimed utilization functions, under the definition of the different relevant -economic and social -agents (Zimmermann, 2006).

While the three principles would require extensive exploration, this research will focus on the information required by the first and second principles, plausibility, and situational validity, to explore alternatives for policy implementation.

II. Novelty, Research Gap, and Policy Case

While most of the mainstream literature has offered stylized facts on how technological change has increased wage inequality, transformed the occupational structure of the labor market, and changed the demand for skills, there is ample space for studying how different countries adapt to technological change to inform policymaking related to the challenges of the 4IR. In this research, I analyze how the phenomenon of technological change presents diversity in its manifestation across countries by focusing on the Chilean experience. I base this decision on three arguments: institutional elements that are distinctive and common across Latin American countries, the problem of policy learning and diffusion related to reskilling or future work agendas, and the issue of technology adoption dynamics.

The literature linking technological change and labor market outcomes has been framed extensively from neo-classical economics. That analysis tends to be biased towards macro trends in the labor market behavior and the availability of evidence from developed countries. Although, the literature has pointed out that there are

different national experiences regarding how technological change affects the composition and occupational distribution of the job market (Adermon & Gustavsson, 2015; Martins-Neto et al., 2021; Oesch & Piccitto, 2019; Sparreboom & Tarvid, 2016). From no impact to institutional factor moderation, the problem of technological change has manifested in diverse ways worldwide. Thus, the possible agendas attempting to uptake the momentum of the fourth industrial revolution should consider the specificities of national economies and their institutional mechanisms to generate positive impacts for social well-being effectively.

Economic systems' organization arises as a factor to be included in the analysis when the dispersion of evidence is considered. The literature on varieties of capitalism (VoC) shows that even countries adopting capitalism as an economic system present different institutional features that account for critical outcomes in economic development and overall economic performance (Culpepper, 2007; O'Reilly, 2006). That could be the source of heterogeneity in the differential impacts across the European Union, the United Kingdom, and the United States, where coordinated-capitalist systems tend to show occupational upgrading as a response to technological change compared to liberal capitalism configurations.

In this regard, Latin American countries, which have shown a resistance reaction to technological change effects on the labor market (Gasparini et al., 2021), tend to be organized as hierarchical capitalisms. According to Schneider (2009a, 2009b), this institutional configuration includes a low educated workforce, an atomistic and short-termed view of labor relations, low power and adscription of unions, and the presence of oligopolies in relevant areas of the economy. Therefore, the initial conditions for technological adoption and the process of technological change present a particular context for the study. For example, the incentives to invest in technology would be limited due to the oligopolistic competency setting, where companies have presented

cartel structures for setting prices and keeping large companies' market share. Regarding the labor relations system, unions have played a significant role in deferring adverse effects of technological change, although they have experienced a decrease in relevance to the overall change in the labor market structure (Kristal, 2019, 2020). The imbalance of power in labor relations and the low share of unionized workers could also play a role in the possibilities for occupational upgrading or deskilling of the workforce.

Chile is an example of this hierarchical capitalism, with recent evidence of how oligopolistic competency has affected consumers and even the representation in democratic institutions (Garin, 2016, 2019). The trends in unionization have decreased considerably over time, reaching a 6.3% of the private sector workforce in 2019 (Dirección del Trabajo, 2019). Regarding workforce qualifications, as in other Latin American countries, the expansion of the educational system began in the first years of the 2000s (Ferreira et al., 2017), with uneven impacts on historically underrepresented groups (Didier, 2021b, 2021c). Still, while the size of the economy is not one of the greatest in the region, Chile has one of the higher GDPs and offers significantly better labor conditions (minimum wage, labor protections) (World Bank, 2020a). In this sense, the Chilean case presents some commonalities with other countries in the region.

The second argument considers the nature of policy transfer, learning, and diffusion phenomena. Policy transfer has been described extensively in the literature as a process of adopting policy ideas from one jurisdiction to another (i.e., country, state, county, municipality) (Benson & Jordan, 2011; Dolowitz & Marsh, 1996; Evans & Davies, 1999). While there are distinctions regarding the nature of the adoption or learning meanings across the specialized literature (Meseguer, 2005; Mossberger & Wolman, 2003), there is an agreement on the complexity of adopting foreign ideas to

the policy system. That is the case of “soft policies” or “hard policies,” differentiating the information about ideas, concepts, and norms from institutional structures, policies, programs, projects, policy instruments, and their implementation process (Stone, 2004).

“Reskilling revolution” and “future of work” agendas operate as an intermixing between “soft” and “hard” policies. Those approaches lead to the projection of some policy instruments (i.e., training programs, skill upgrading, educational expansion), assuming the effects of the third industrial revolution on labor market structure. However, the same policy instruments (active labor market policies) have shown diverse impacts concerning their targeted outcomes based on institutional factors and economic systems (Almeida & Aterido, 2015; Bergemann & van den Berg, 2008; Caliendo et al., 2011; López Mourelo & Escudero, 2017). In the case of Latin American countries, the evidence regarding the operation and impact of the intended policy tools is diffuse, holding different quality characteristics in the analysis (Didier & Cox, 2012; Ramirez-Anormaliza et al., 2017; Talleri et al., 2013; Villar et al., 2013). The provision of situated evidence could enhance policy transfer and learning possibilities, considering the shared features across the countries and the everyday challenges their economies face.

The third consideration comes from the dynamics of technological adoption. One of the assumptions in technological change literature is the pervasiveness of those technologies across countries as if technological adoption occurs similarly (Santos et al., 2017). Still, the evidence from regional sciences shows that even in the same country, the propensity for technological adoption varies in the territory (De Propriis & Bellandi, 2021). The historical process of Latin American countries has included a significant problem of technological adoption, showing resistance to including new technologies in the production process from companies and consumers (Chong &

Micco, 2003; Datta, 2011; Grazzi & Pietrobelli, 2016; Maloney, 2002; Montealegre, 1998). In the case of Chile, the open economy model adopted in 1980 and developed during the 1990s led to a faster pace of technological adoption of ICTs than in other countries in the region (Drees, 2022; Messano, 2013; World Economic Forum, 2022), turning the Chilean experience interesting for policymakers across the region to translate policies from a country with a similar cultural background and historical experience in the relationship with new technologies.

III. Research Objectives

The general objective of this research is to provide a comprehensive assessment of the process of technological change in Chile, considering the specificness of the socio-historical and Chilean institutional settings. In other words, I attempt to provide evidence regarding the fit of the narratives of technological change in a high-income developing economy and the institutional features of education and labor market coordination that could play a role in the manifestation of stylized facts regarding technological change effects in the labor market.

In addition, this research has the following specific objectives:

- (a) Provide a synthetic understanding of the evolution of the relationship between technology and labor from the industrial revolution's perspective.
- (b) Connect phenomena related to the evolution of educational credentials with the historical development of the third industrial revolution.
- (c) Develop a comprehensive framework connecting the evidence, discourses, and representations from the third industrial revolution with the current understanding of the potential effects of the fourth industrial revolution.
- (d) Compare the narratives of technological change with the socio-historical experience of Chile through a case study covering the evolution of the Chilean

economy, the technological ecosystem, the structure of the labor market, wage distribution, and educational attainment.

- (e) Discuss the essential elements and considerations to develop just labor transition policies for the workforce, considering the policy environment and historical reaction to technological change.

IV. Document Structure

This document is structured across six different chapters. The first two chapters cover an overview of the evolution of the labor realm across the third and fourth industrial revolutions (chapter 2) and the adaptation of educational systems across both processes (chapter 3). The fourth chapter presents an empirically grounded workforce adaptation model that encompasses and connects the effects and dynamics of the 3IR to the forecasted scenarios of the 4IR. Chapter 5 presents the case of the Chilean process of adaptation to technological change, including the evolution of technological adoption patterns, issues regarding the polarization process by itself, the evolution of availability of the leading technologies for the third and fourth industrial revolutions, and the evolution of wages, occupational structure, and workforce educational attainment between 1990 to 2018. Finally, chapter 6 problematizes the design of just labor transitions.

CHAPTER 2

TURNING FRAGMENTS INTO A LENS: TECHNOLOGICAL CHANGE, INDUSTRIAL REVOLUTIONS, AND LABOR

Section 1. Introduction

Technology has been one of the significant drivers of labor market change. During the last sixty years, disruptive technological innovations have reshaped how societies understand labor, affecting the traditional understanding of occupations and how resources are allocated in the production process (Ojala et al., 2016; Perez, 2007; Reijnders & de Vries, 2018). Technological disruption and adoption processes in that period can be clustered into two major groups: the third and fourth industrial revolutions. Both moments have implied several changes in the production process, changing the balance between production factors: capital, labor, and technology.

While there is an agreement on the definition of the first two industrial revolutions, the third and fourth industrial revolutions have a fuzzy definition depending on the discipline in which they are conceptualized. The first and second industrial revolutions were defined by the availability of a new energy source that fueled the mechanization of the production process. The first industrial revolution refers to the enormous social and economic changes produced by the invention of steam engines and the availability of steam-powered machines for use on an industrial scale. The second industrial revolution was driven by gas and electricity as energies to power up industrial

production, increasing the economic performance of diverse economic sectors (Perez, 2004). The third industrial revolution was associated with the availability of nuclear energy (Drucker, 1969) and later with new technologies such as computers and IT (Mowery, 2009). This shift between energy-centered technological development was overpassed by the relevance of including computing technologies in the workplace, redefining the value of labor from physical capacity to more complex tasks (Liu & Grusky, 2013). Finally, the fourth industrial revolution takes the advance of IT and computing power to fuel a change in the landscape of industrial production (Fuchs, 2020). Concepts present in the prior industrial revolution appear revamped in this technological change process, taking the notions of automation and digitalization (replacing routine tasks with computers) but translating them into a digital economy frame (e.g., cyber-physical systems. A.I., and decision-making algorithms).

The main consequence of scholarly research has been disentangling discourses and narratives on technology's impact on the economic, labor, and social spheres. However, neoclassic economic research has historically rejected the frame for industrial revolutions, using the generic term technological change to describe the evolving relationship between technological change and labor allocation (Acemoglu & Autor, 2011). From the economic research perspective, concerns regarding the technological impact on the labor market assume a linear relationship in the production function (Yuhong & Xiahai, 2020). The labor-centered analysis will cover individual reactions to occupational and educational choices, dealing with the changing nature of the labor market (Chesters, 2014; Vidal, 2013). Social-centered interpretations will focus on how technologies change daily life, the interactions between consumers and producers, access to goods and services (Frey et al., 2018; Kostakis et al., 2016), and social interactions mediated by technology, among others.

This diversity of focuses and narratives used to frame the technology-labor relationship makes it difficult to navigate the connections between elements, related conceptualization, and empirical approaches to study them. That is the case of the study of technological disruption effects in the labor market, where the concept of technological change is used to describe the dynamics of the third and fourth industrial revolutions, even when both periods are characterized by different technologies (e.g., computerization and digitalization) and have different levels of influence on the production process and pervasiveness.

This chapter aims to describe and summarize the phenomenon related to technological change, framing the timing of the process of the third and fourth industrial revolutions. The analysis focuses on what transformations in the labor market accompanied both processes of technological change, crafting a policy narrative on the main element that explains those transformations. The rest of the chapter is organized as follows: Section 2 examines the process of the third industrial revolution, its associated technologies, and the outcomes for the labor market. Section 3 describes technologies associated with the fourth industrial revolution and the expected outcomes for the labor market. Section 4 summarizes the consequences of both industrial revolutions from a historical perspective of workers, companies, and government. Section 5 presents the concluding remarks and stylized facts regarding the evolution of the technology-labor relationship.

Section 2. The Third Industrial Revolution

2.1. Technology, Computerization, and Labor Markets Outcomes

The first problem is defining the characteristics and nature of the third industrial revolution comes from the notion of the “industrial revolution.” The idea of

technological change is part of the long discussion between economic paradigms, focusing either on the specific technology as a neo-classical economic approach or on the long waves of change in the socio-economic understanding of technological disruption. The first view will consider technology as a factor or condition in the production function and include it in an empirical analysis as a single enabler or barrier for achieving optimal productivity. The second approach represents a neo-Schumpeterian view of technological change, emphasizing the type of innovation, its characteristics, and the socio-institutional elements that define the techno paradigms (C. Freeman, 1995; Perez, 1985).

While the neo-Schumpeterian approach would be more suitable for framing economic development policies and understanding the social process, the neoclassical perspective is the dominant approach to analyzing the effects of technological change on production. Consequently, most definitions of the effects of the third industrial revolution consider that kind of perspective on its reasoning. In this case, the third industrial revolution, broadly defined by the literature, considers the proliferation of computers in the workplace and the increased relevance of ITC as a production factor. As was mentioned, the availability of new energy sources led to transformations in the industrial production process (Rifkin, 2011), while in the third industrial revolution, machinery, specifically computing power, made a difference in the productivity of companies.

Focusing on the “specific machinery” related to technological disruption has dramatically impacted how scholarly research is framed as technological change. That is especially true in excluding managerial and production system design from the economic analysis, neglecting the impact on the sociotechnical system dimension of technological change. For example, Cooper and Kaplinsky (2005) define that the main change from the third industrial revolution was the transition from mass production to

flexible specialization. The rationale for how industrial production reacted and developed new technologies included restructuring the production process to respond to demand-side requirements. That was also accompanied by managerial techniques and strategies, including six sigma and just-in-time (Mitra, 2004; Snowden, 2002). Still, the mainstream approach considers as critical the inclusion of computers (Autor et al., 2003; Howell & Wieler, 1998) and ICTs (Arvanitis & Loukis, 2009; Eden & Gaggl, 2019; Jorgenson & Vu, 2016) as defining elements of the current technological change process.

At a macro level, the extensive process of technological change associated with the neo-classical view is associated with three major processes: deindustrialization of developed economies, workplace computerization, and the rebalance of marginal productivity assigned to technology and labor. Those elements are part of the core discourse or narrative of technological change and can be found with different levels of relevance in empirical research. Also, that combination of elements contextualizes problems related to wage distribution, industrial, training, and trade policies (Cirillo et al., 2017; Felstead et al., 2000; Furusawa et al., 2020; Kurokawa, 2014), among others.

Historically, the question regarding technological change impacts arose from a consistent observation regarding the increasing levels of inequality in developed countries (Howell, 1999; Juhn, 1999; Watson, 2002). An inspection of that inequality provided a stylized fact: the stagnation and compression of wages were skill-biased, being the high-skilled jobs with real growth in their value compared to low-complexity jobs (Autor et al., 2008; Gottschalk, 1997). That was the first inspiration for the skill-biased technological change hypothesis developed by Katz and Autor (1999), which stated that the industry transformation from the seventies led to wage polarization in the job market.

The economic analysis of what happened in the seventies included the deindustrialization process of developed countries through massive offshoring strategies of manufacturing companies (Harrison & Bluestone, 1990; Hobor, 2013; Peck, 2002). The labor market processed offshored jobs as a “job destruction process,” reallocating workers in the growing service economy. However, the reallocation process was suboptimal for the individuals due to the lack of transferability between the manufacturing industry's skill sets and the service economy. Manufacturing industries that used to hire and need a semi-skilled workforce decreased their relevance on the demand side of the labor market.

Simultaneously, the emerging technologies labeled “workplace computerization” impacted the labor market by replacing labor as a production factor. Routinized jobs were displaced by technology (perfect substitution), while others were downgraded (partial substitution) (Connolly & Gregory, 2008; Goos et al., 2019; X. Wang, 2020). In economic literature, this phenomenon has been described as the routine-biased technological change hypothesis (RBTC) (Goos et al., 2014) and represents the dynamic by which routinized occupations experienced a change in their job’s task contents.

The routine-biased technological change hypothesis is an explanatory mechanism for skill-biased technological change. It has two significant consequences: the polarization of income distribution (bi-modal distribution) and the polarization of the job market regarding occupations (Sparreboom & Tarvid, 2016). The difference between both ideas comes from the employment-wage relationship. High-skilled workers are assumed to be at the top of the wage distribution, and low-skilled workers are at the bottom due to the classical association between wages-productivity and skills (Gabe & Abel, 2011; Klein et al., 2013). The polarization appears as a shrinkage of medium-complexity jobs in the middle of the wage distribution, favoring a more

significant share of high- and low-complexity jobs (Fonseca et al., 2018). However, the perspective on occupational structure emphasizes which occupations are less demanded, being the complexity of the job or occupation built from the task dimension and the skill sets to perform them in the labor market.

2.2. Knowledge and ICTs Workers

The centrality of computerization as the critical element for the third industrial revolution had an additional consequence for the labor market: the emergence of knowledge workers. Workplace computerization affected the task contents of jobs and created a demand for computer-related skill sets. That shift in the demand for skills impacted the expectations about what skill sets were available in the workforce (Cappelli, 2015; Maclean & Ordóñez, 2007) but also pressed for higher degrees of specialization according to the role: maintenance, systems control, development, and supervision for informatic infrastructure.

This second ICT-facet of the third industrial revolution links the issue regarding automation by computerization to the next step in economic development: the age of information and communication technology (C. Freeman & Louçã, 2004). The relevance of this shift is to separate the direct experience of traditional manufacturing industries from the spillover to other economic activities. As expected from the specialization process, not all workers displaced from traditional occupations could upskill/reskill their abilities to the new requirements. Estimates for OECD countries show that technological change increased the demand for skilled workers, being a small fraction of them reallocated into ICTs roles (Böckerman et al., 2019; Greenan et al., 2001; Machin, 1996; Machin & Van Reenen, 1998; Piva et al., 2005). Still, ICTs workers have received more significant skill premiums than other highly-skilled occupations (Gallipoli & Makridis, 2018).

The age of information and communication technologies stimulated the development of the knowledge economy and increased the need for specialization in the workforce. Knowledge began to be considered an asset that should be managed to produce competitive advantages (Kakabadse et al., 2003; Sieloff, 1999; M. E. Smith, 2003). Furthermore, at the center of that knowledge management was the IT infrastructure, a technology enabler for preserving, sharing, and growing the intellectual capital of companies and organizations (Dibiaggio, 2007). At a slow pace, the new form of high-skilled workers related to technological tasks and industries began to receive differential treatment by human resources, management, and scholarly research, naming them as knowledge workers in their own right (Marks & Baldry, 2009; O'Leary-Kelly et al., 2014; Shani et al., 2000).

While computerization changed the structure of organizations and their labor relations (Knutsson, 1986; Telem, 1998; Vuillemin, 1989; Wolfe, 1989), the emergence of the new form of skilled workforce reshaped the labor market's images of professionals and skilled workers (Prasad & Prasad, 1994). That image is pervasive for what is assumed in the future of work agenda, including the need for a continuous update on skills due to technology obsolescence (Kelan, 2008; Rabayah & Sartawi, 2008), the key to remaining competitive by their role in knowledge management practices (Ambrosini et al., 2009), the ability to translate abstract production designs into the actionable process through computation and codification (Greenan & Guellec, 1994), and a constant situation of skill shortage (D'Costa, 2003).

However, one of the most relevant characteristics of this new kind of worker is the link between technology and skills. With technological development, ICT workers experienced a considerable redefinition of the skill sets to be successful in the labor market, from providing technical support for hardware and the maintenance of IT infrastructure to informatic system development and the development and

maintenance of internet-based applications. With technological disruption and obsolescence cycles, this range of technological domains has pushed for specific practices for workforce management (C. L. H. Chang et al., 2012; Lockwood & Ansari, 1999; Marks & Scholarios, 2008). For example, the increased relevance of certifications over college degrees for hiring decisions (Crawford & Mogollón, 2010). The systemic effect of this market configuration press for the modularization of knowledge clusters to fulfill the roles associated with IT workers, making for apparent differences between general human capital and task-specific human capital and its acquisition sources.

Section 3. The fourth industrial revolution

3.1 Defining the 4IR

As predicted during the first decade of the 2000s, advances in science and technology - particularly those related to computational sciences - significantly impacted how societies live (Yudowsky, 2008). Applications of data science and artificial intelligence have begun to reshape the notions about what social expectations of the future are, how the economy works, and possibilities for sustainability in industrial organizations, among others (Agrawal et al., 2019; Allam & Dhunny, 2019; Främling et al., 2013; Hamori & Kume, 2018). The fourth industrial revolution (4IR) has emerged as a broad framework to describe how those technological changes offer to reshape the world (Schwab & Davis, 2018).

The 4IR has included in its development the creation of new tools that have changed how customers relate to producers (Baines et al., 2020; Syam & Sharma, 2018), citizens relate to politicians, employers relate to employees, and untimely how individuals define themselves (Kapoor, 2014). Those tools include creating, implementing, and developing digitalization, Information and Communications

Technologies (ICTs), machine learning, robotics, Artificial Intelligence, and those advances framed into computer sciences (Gupta et al., 2017).

Implementing upgrades in the production chain has aimed to increase efficiency across each activity, meaning various modifications in the production process. For example, new technologies have influenced the manufacturing process allowing the change from mass production to customized production, using tools and strategies such as digitalization and process redesign using computer sciences (Vaidya et al., 2018). However, the perceived benefits of technological advances in production processes have unintended consequences that directly affect workers' projected job loss. Implementing new technologies in the production process includes replacing human labor with machines or systems that provide automated decision-making (Carvalho et al., 2018; Min et al., 2019).

3.2 The Industry Side of the Equation: Industry 4.0

Industry 4.0 and "industrial Internet" has been the concept that summarizes the evolution of production systems given the technologies associated with the fourth industrial revolution (Shaffer, 2021). Habrat (2020) defines industry 4.0 as an intelligent factory with an automated adaptation of production structures and systems according to the order's nature and considers four technological pillars: cloud computing, the internet of things, cyber-physical systems, and Information and Communications technologies. Those technologies interact in manufacturing, adding a deep integration between broadly defined intelligence and networking (G. Li et al., 2017), including adapting previous managerial practices as lean management and quality management tools (Boobier, 2018).

This broad understanding of industry 4.0 overlooks the manufacturing system's infrastructure dimension, including the considerable advances in sensors and connectivity between systems (S. P. Lee et al., 2019). Internet of things technologies

allow companies to connect different physical components of the production process with the internet, providing real-time information about its performance and operation (Aly et al., 2021). Cloud computing technology implies a shift for companies to have their IT infrastructure and use an internet connection to enhance their computing capacity making the information collected by companies available online (Onu & Mbohwa, 2021). Cyber-physical systems allow adapting to the manufacturing process using the information regarding the operation of process components and information in companies' data marts through programmed decision-making algorithms (Fuchs, 2020). This articulation of technologies relies on ICT capital and workers to support the production process.

This way of organizing production in the manufacturing industry is the key to forecasting the analysis of the impacts of the fourth industrial revolution (World Economic Forum, 2020b). However, innovations in the manufacturing industry can produce a new age of prosperity by optimizing the use of resources such as energy (Dogaru, 2020; Tang et al., 2019) and decreasing industrial waste (Mendoza-Del Villar et al., 2020). Still, the impact of these technological advances will depend on the institutional framework (Fukuda, 2020). The policy environment and regulations will play a key role in adopting the new technologies and mediating the possible impacts and consequences on economic development and market behavior.

Section 4. The Future of Work? Digital Economy and Digitalized Labor

Similarly, as the knowledge economy and migration to the service economy fed the third industrial revolution, the fourth industrial revolution is supported by the emergence and expansion of the digital economy. The digital economy considers the effects of digital technologies on trade and business models, like implementing the "smart factories" of industry 4.0 and the platform economy (Hörnle, 2012; Lehmann

et al., 2019; Peitz & Waldfogel, 2012). The dimension of digital trade and economic exchange through e-commerce platforms is critical for analyzing industry change potential, being considered central in World Economic Forum reports (2019).

From this point, for the discussion on the “future of work” agenda, it is necessary to differentiate between the beginnings of the digital economy on its trade dimension from platform economy evolution. The first dimension was the direct effect of internet availability expansion and started as another commercialization strategy, complementary to physical distribution and even mail-based purchases (S. F. Lee & Lo, 2003; Wei Choo & Johnston, 2004). During the adoption process of electronic commerce, companies began to develop new business and management practices to take an edge in this new environment (Byrom et al., 2002; C. Collins et al., 2003; Neill & Mulholland, 2003). Still, as a commerce channel, the first focus was supply chain management and process optimization for goods distribution (Harris et al., 2001) rather than service provision.

A platform or gig economy appeared in the second stage by taking the service provision dimension. Gig economy business models are based on coordinating supply and demand for services, treating workers as “independent contractors,” and avoiding general labor laws' regulations and obligations (Kaine & Josserand, 2019). The gig economy approach allows companies to decrease human resources costs and provide flexibility in the links between suppliers and customers, getting a fee for that coordination (Josserand & Kaine, 2019; Spreitzer et al., 2017). For some researchers, this business model affects the understanding of labor relations systems, showing different impacts on workers' characteristics, such as age and gender (Caines et al., 2020; Foley et al., 2020; Petrongolo & Ronchi, 2020).

The digital environments for economic exchange and shorter and less intensive value chains have raised questions about the “future of work” and the “future of jobs”

(OECD, 2018; World Economic Forum, 2021). Even with some degree of complementarity between both concepts, they represent different phenomena. The future of jobs agenda is based on the economic dimension of labor, focusing on job-occupation forecasting, the availability of jobs, and their skills (Mashelkar, 2018; OECD, 2020; World Economic Forum, 2020b). The approach to the future of work includes a broader perspective on transforming the nature of work, labor relations, and the sociotechnical imaginary associated with work activities (Lewis & Bell, 2019; Lühthje, 2019; Schiølin, 2020).

As a trajectory for the analysis of the labor-technology relationship, “future of work” agendas will be defined by a combination of the diverse factors aforementioned: job flexibility-insecurity and atomization of the labor relations, automation, and digitalization effects on employment, increased obsolescence of technological skills, and the accelerated transformation for manufacturing and service economy due to technological change. However, the historically recent process of the third industrial revolution and its effects on employment, automation, digitalization, and the skills for future jobs are at the center of the economic debate.

The economic debate has been reexamining the labor-technology relationship using the lens of the fourth industrial revolution. While computerization displaced workers by replacing routine tasks, new technologies such as Artificial Intelligence and Machine learning allow companies to automate decision-making processes (Ernst & Ernst, 2019; Huang & Rust, 2018). Automating decision-making implies replacing the human factor by removing a high-level cognitive process from the production process, one of the defining elements of skill-biased and routine-biased technological change. That element applies to the manufacturing industry (i.e., “smart factories”) and service economy companies (i.e., chatbots and automated customer service platforms).

From this point, the debate deals with high levels of dispersion. The reskilling revolution of the World Economic Forum (2019) states that the ability to take up the competitive advantage of the fourth industrial revolution will be mediated by the availability of specific digital skillsets. Additionally, countries must update their definitions of the task associated with the new jobs or occupations that “smart industries” require (World Economic Forum & Centre for the New Economy and Society, 2018). Still, the technologies included in the fourth industrial revolution definition (Schwab, 2018) bias the analysis towards industries such as manufacturing and service economy activities like information technology, financial, transportation, and packaging (Mehta & Awasthi, 2019). In the case of occupations, the bias will favor digital-related skills occupations, ranging from data analytics, data visualization, and programming, among others. The impact of new technologies would not be over the entire labor market, and the most affected jobs would be the technology-specific occupations replaced by automation and digitalization.

However, this focus on the technostructure of companies and industries limits the reach and scope of technological change. More minor technology-dependent occupations could face a different fate, considering the nature of specialization for non-educational-dependent jobs (ISCO major groups 4-9). That is consistent with scholars’ argument about that the labor-technology complementary-substitution relationship is occupational-specific (i.e., personnel selection professionals and personnel selection algorithms (Chamorro-Premuzic et al., 2017), organizational development professionals, and people analytics (Tursunbayeva et al., 2018) or industry-specific (i.e., finance services (Tao et al., 2021)), tourism industry (Manthiou et al., 2021) rather than a property of the general labor market (Willcocks, 2020).

Section 5. Considerations for Research Development

In the pervious sections, I described the evolution of the relationship between technology and labor from the perspective of "industrial revolutions." Since the seventies, technology has reshaped the labor market structure in different ways, changes that were enthusiastically addressed by economics, sociology, management, and other disciplines. During the third industrial revolution, technological change mainly referred to workplace computerization and later to the proliferation of ICTs. In the case of the fourth industrial revolution, the narratives include the digital economy expansion process, the gig economy, and the challenging scenario for industrial relations and economic performance.

Following the historical evolution of the phenomena, scholarly research has defined the technologies involved in technological change as hardware: computers, semiconductors, processors, and sensors. At the same time, the reference to the software includes operative systems, networks, informatics systems, and, more recently, digital platforms. In this setting, the study of technological change should consider the specificness of technologies included in the analysis and the cumulative effect when time is considered a relevant variable.

Any analysis of the effects of technological change in the labor market should consider the education and training dimensions to isolate this essential element in the impact assessment. Another element is the educational market's response to labor market changes. The continuous diagnosis of skill shortage and formal education or training have been addressed for educational systems in a diverse fashion (Cappelli, 2015; Montresor, 2019). Some countries have made decisions regarding their strategies to cope with the changing requirements of the labor market through modifications to the school curriculum like in the case of the skills for the 21st century in the United States (Pellegrino & Hilton, 2013) or Indian reform to account for the future skill shortage (Bhandari et al., 2021). This category also includes the process

of educational system expansion and the increased accumulation of human capital in the workforce.

Finally, technology also impacts the layout of the work environment. That has also impacted how people access the critical skills requested from the labor market. That is the case of including new technologies to cover the skill shortage, as in the case of e-learning programs (Webb, 2006) or online certifications (Finkelstein et al., 2013; Slotte & Herbert, 2006). In this sense, access to skill development has also experienced a change that should be considered for technological change impact on the workforce, whether following standard practices in the ICT sector or reducing the difference between the educational and working environment (Blume et al., 2010),

**CREDENTIALS MEET THE FOURTH INDUSTRIAL REVOLUTION: THE LEGACY
OF THE KNOWLEDGE ECONOMY**

Section 1. Introduction

The fourth industrial revolution (4IR) is here. This statement has been repeated in business and policy forums to summarize disruptive technologies' adoption in production processes (Schwab, 2018). Those technologies include robotics, digitalization, cyber-physical systems, and applications that have begun to reshape production systems' possibilities (Mubarak & Petraite, 2020). As the World Economic Forum (WEF) has been promoting since 2016, those technological changes are affecting it. They will modify the labor market landscape, shifting the demand for skills and appearing more complex or sophisticated digital-related skills (World Economic Forum & Centre for the New Economy and Society, 2018).

How do technologies change the labor market? The economic perspective on this issue argues that technology changes the balance between physical/financial capital and labor as factors in the production process. Those shifts in the balance have been represented in the literature using the concepts of automation and computerization (Goos et al., 2019; Vermeulen et al., 2018), where tasks and occupations have been transferred from workers to a digital-system sphere. That change could be in job design, using computers to perform routinized jobs, or at the production system level, where algorithms make decisions and disappear from direct human supervision. In both cases, the job complexity changes, and consequently, the relevance and value of those jobs.

Literature supports the idea that including new technologies in the workplace changes the demand for skills, altering the wage distribution and the quality of employment, among other effects. Currently, there are heterogeneous forecasts regarding the magnitude of changes related to the labor market carried out by the fourth industrial revolution (Willcocks, 2020; World Economic Forum, 2020b). Within that heterogeneity, the role of skills and abilities appears to play a relevant role still. Since the changes in the labor market operate at two levels (job and system), it is difficult to seize all the direct effects of the current technological change. However, the literature has offered a solid base to judge the effects of technology change on labor relations and income by studying previous processes, such as the computerization of the workplace (Fuei, 2017; Gatta et al., 2009; Wolff, 2005).

The WEF has forecasted the change in skills and occupation demands in the future and promotes its agenda to cope with those changes at the national economy level. WEF proposal has been labeled as "the reskilling revolution" and implies a plan to train one billion people for 2030 (Cann, 2020) in the "skills of the future," allowing companies to remain competitive and national economies to increase their economic growth. In simple terms, the reskilling revolution implies the growing need for people to train constantly to acquire new digital-related skills (World Economic Forum, 2021) and the development of a private solution for those training needs. This formulation of the reskilling revolution is coherent with the evolution of lifelong education policies in Europe and the literature on lifelong learning for less-regulated training industries (Ala-Mutka et al., 2010; Tønseth, 2015).

Nevertheless, a policy response to technological change and the problem of technological unemployment cannot be only concerned about how the circumstances may change. It also should consider how previous policies and institutional arrangements have produced specific labor market configurations and how the

envisioned policies could interact with the current situation. Since the mainstream discourses on reskilling revolution and the future of work highlight skills acquisition as the primary strategy to cope with technological change, it is necessary to review and understand the institutional background for the interaction between education and labor markets regarding the understanding of those skills and the mechanisms is to certify the possession in the workforce. This chapter attempts to summarize the co-evolution of labor and educational markets through a literature review regarding educational credentials and the emergent trends from educational policies implemented during the same period. The rest of the paper is organized as follows: in section 2, I summarize the two leading theories on educational credentials from economics and sociology. Section 3 presents the relationships between lifelong learning policies, technological change, and the evolution of credentials relevance in the labor market. Section 4 explains how the context of the fourth industrial revolution and the narratives of the future of work stress the institutional background of credentials as coordination devices between labor and educational markets. Finally, section 5 proposes a research agenda on understanding the economic impacts of credential evolution on educational and labor policies.

Section 2. The Role of Educational Credentials in the Labor Market

Credentials are one of the significant coordination devices for the educational and labor market. For the educational market, credentials, certificates, and licenses are the outcomes by which educational institutions are measured and compared. That is the case of enrollment rates, selectivity, completion rates, and even the perceived prestige given the quality of the students' performance in the labor market (Altbach, 2012; Quacquarelli Symonds, 2020). For labor market institutions, credentials represent a signal to prospective workers regarding their level of skills and future

productivity (Walters, 2004). It also holds a reciprocal relationship between both markets as a coordination device. For example, companies can require new ways to certify and formalize the contents of some skill sets related to their production structure.

Educational credentials, as coordination devices, have different levels of analysis given the interactions between individuals and firms in the institutional environment provided by the national culture and economy. That complexity has been studied from economic and sociological perspectives, providing insights into its nature and impact on social mobility. From a historical perspective, credential ability to represent skills and status has dramatically evolved during the twentieth century due to the expansion of higher education and its correlates in the supply of specialization alternatives (i.e., diversity of undergraduate and graduate programs) (Isopahkala-Bouret, 2015b) and later by including certifications for technical and professional skills.

The credentials' economic frame is primarily based on Screening (Stiglitz, 1975) and Signaling Theories (Spence, 1973). Both theories have a similar starting point on the coordination problem between economic agents (individuals and firms) with a hiring/recruitment decision. Since an individual worker's skill and future productivity levels are unknown to prospective employers, firms tend to offer salaries with a wage penalty to compensate for the risk of unmatched needs of jobs. On the other side of the equation, individuals must signal to potential employers their future productivity levels to increase their chances of being hired and receiving appropriate compensation for their work. Educational institutions offer a way to reduce information asymmetry by certifying the skill sets present in the workforce through credentials.

The credential acquisition does not come without effort and resources. According to the signal theory, individuals will invest in education (a mechanism to acquire educational credentials) until the economic benefits of obtaining a credential equal the

cost. Consequently, educational credentials produce a sheepskin effect (Bilkic et al., 2012), where the workers who finish an educational level are qualitatively different from those who drop out of their studies. The sheepskin effect appears as an additional determinant of the skill-wage relationship, showing consistent evidence worldwide of a significant effect on wages (Arabsheibani & Manfor, 2001; Ferrer & Riddell, 2008; J. Gibson, 2000; Patrinos, 1996). Those effects persist even when the research design control for human capital variables as defined in the Mincerian equation of wage determination (Mincer, 1958).

However, the ability to signal skills and future productivity of credentials is accompanied by the social representations of its effects and consequences, namely prestige, job quality, higher wages, and social background, among others (Tomlinson, 2008). Sociological theory has developed a critical understanding of that dimension of credentials, represented by the concept of educational credentialism (R. Collins, 1979; Zajda, 2013). Educational credentialism argues that credentials operate as social markers, allowing prospective employers to distinguish between applicants by the social background represented in the credentials. This perspective, mostly centered on the role of colleges and universities as a source of labor market inequality, presents a series of distinctions related to higher education expansion, the massification of undergraduate programs, elitist configurations, and problems of graduate employability (D. K. Brown & Bills, 2011; Isopahkala-Bouret, 2015; Marginson, 2016).

A sociological interpretation of credentials carries two significant problems for the labor market structure. First, if prospective employers consider the information on social background contained in the credential and make decisions based on that information, then those employers will be making biased (discriminatory) decisions. That biased strategy for decision-making can be found in the diverse use of credentials in the recruitment/hiring process at the firm level (Buon & Compton, 1990; Saar et

al., 2014), and the long-run effects could be found in the disentangling in the skill-credential relationship (Araki, 2020). Second, if individuals are unaware of the double dimension of credentials, they will be dragged into a race to obtain advanced credentials (graduate degrees) that are not required to fulfill their jobs. This second phenomenon is called credential inflation (P. Brown et al., 2016; Van De Werfhorst & Andersen, 2005) and refers to companies' practices requiring advanced degrees regardless of the task complexity involved in a job. In this context, individuals are forced to acquire higher levels of general human capital, even for occupations that do not require extensive specialization.

While contradictory in the primary interpretation of credentials, both dimensions of credentials (skill/productivity and social background) directly affect wage distribution, even showing interactions between the credential provider and the credential itself (Didier, 2021b). At a macro level, the distortion in hiring practices and the pressure for enhanced human capital accumulation have fueled the expansion of higher education enrollment, forcing a new equilibrium in the labor market. Higher education expansion has changed the scarcity-availability of skill sets, affecting those skill sets' reward structure (Brooks & Everett, 2009; S. J. Smith & Urquhart, 2018; Telling, 2018). The lack of fit between labor markets' supply and demand for skills represents friction in the labor market with consequences on wages, employment, and even life satisfaction (McGuinness & Sloane, 2011; Thompson et al., 2013).

Section 3. Credentials, Lifelong Education, and Technological Change

3.1. Credentials Evolution and Lifelong Education

Linked or parceled, credentials as a coordination mechanism have experienced a significant transformation in their ability to represent social meaning during educational expansion since the early eighties. Credentials' dual understanding is still

rare in the literature due to the difficulty of presenting robust strategies to isolate institutional reputation, social representations, and workers' socioeconomic backgrounds from the credential valuation. Also, a more complex analysis would need to reconcile the difference in research interest for both traditions. For example, focusing on the sheepskin effect will bring issues to the discussion about the relevance of finishing educational cycles as indicators of successful educational policies (Mora, 2003; Mora & Muro, 2008). The focus on educational credentialism would be more linked to social reproduction and mobility interests, depicting why families fail to change their social class even with a more significant accumulation of human capital across generations (Chillas, 2010; Fogarty & Zimmerman, 2019; O'Dwyer, 2020).

Although higher education expansion is a phenomenon that occurs worldwide, its timing and institutional manifestations vary broadly across countries and regions. A significant section of educational mismatch literature is grounded in the experience of industrialized countries that developed an expansion of their higher education even before the eighties decade, as in the case of the United States and the United Kingdom (R. Freeman, 1976; Groot, 1996). In other regions, the same expansion began during the late nineties and in the first decade of the 2000s (Chiroleu & Marquina, 2017; Hao & Zhang, 2020; D. H. Kim & Choi, 2015). Differences also accompanied the timing difference in educational expansion, such as the behavior of social structures and the underlying social stratification (Inglehart, 2015). That interaction between the social structure, the increased access to higher education studies, and the re-organization of national economies related to globalization have influenced how related phenomena to higher education have been expressed (e.g., educational mismatch, elitist higher education, prestige related to occupations). For example, the population's percentage with tertiary education moved between 1990 and 2010 in the largest economies of the European Union from 13.4 to 24.74% (World Bank, 2023). In comparison, the largest

economies in Latin America and the Caribbean increased from 10.65 to 14.87% in the same period. As a benchmark, the United States increased its population with tertiary education from 43 to 53.94% and Canada from 20.77 to 43.1% in the same period.

In that historical expansion process, the value of credentials suffered a redefinition given to the variations in scarcity/supply of skills in the workforce and the significant economic transformations due to the deindustrialization of developed countries and the migration to a service economy. That economic transformation was accompanied by concepts such as the knowledge economy, knowledge society, and intellectual capital, that articulated the need for advanced skills and knowledge to remain competitive during globalization (Abeysekera & Guthrie, 2004; Frericks et al., 2010; Kormanik & Shindell, 2014; Sharma et al., 2009). Moreover, the development of knowledge-based assets increased the demand for skilled workers with different skills than those required by industry-based economies.

The migration to a service economy pushed for a continuous upskilling or reskilling of the workforce, mixing the instability conditions of labor relations with a specific solution: lifelong learning as the key to employability (Berdrow & Evers, 2014; Egerton, 2000). As a policy strategy, the lifelong education approach placed the responsibility for the employment-unemployment situation on individual decision-making about how and when to update the skills. Different governments in Europe crafted educational systems development in a "cradle to grave approach" (Braathe & Otterstad, 2012; Preece, 2010; Tight, 1998), where educational institutions were commended for developing training schemes allowing people to keep updated on the skills and competencies required by the job market. Subsequently, labor markets faced growing completion rates of undergraduate studies and increased specialization programs' availability.

Those effects in the coordination between labor and educational markets are well represented in research regarding employability, school-to-work-transition, educational mismatch, and older workers' career strategies (McQuaid & Lindsay, 2005; Montizaan et al., 2010; Ordine & Rose, 2011; Sánchez-Sánchez & McGuinness, 2013; Yeung & Yang, 2020). The labor market began to respond to the oversupply of education-based credentials by lowering graduate employability and wage premium (L. Arthur, 2006; Jackson & Chapman, 2012; Rae, 2008). An alternative from those pure education-labor coordination problems emerged from management literature, emphasizing "soft skills" relevance in the service economy and the key to a successful career (Nevile, 2004; Nickson et al., 2012).

However, the critical problems for credentials remained at the center of the resource allocation problem, portraying a trend to not rely on formal qualifications-credentials but seeking interpersonal skills and competencies as a differentiation factor in hiring decision-making. The effectiveness of credentials as coordination devices between education and the labor market were hindered, establishing new base-level assessments for traditional education credentials and assuming new criteria regarding the value of skill-based certifications.

Since the economic transformation followed a fast-speed pace in allocating competitive advantages to workforce skills, two responses appeared from the institutional domain. The first was repurposing advanced degrees to professional development requirements or turning them into more industry-focused (Anleu & Mack, 2008; Zusman, 2017). The second was a more articulated process of formalizing training providers and the mechanisms to obtain a certification (Acemoglu & Pischke, 2000; Busemeyer & Vossiek, 2016; O. F. Rodríguez et al., 2011). This second type of credential was not assimilated into educational degrees, allowing more flexibility in acquiring them as pivots for career development (Yerger, 2017). The reduced cost of

that kind of credential allowed a more fluid human capital accumulation process, being less costly, industry-recognized, and short-term as human capital investment. Still, the valuation of those kinds of credentials depended on the institutional conditions of each country (Didier, 2018a), showing several difficulties in expanding the narrative of lifelong education outside the sphere of developed countries.

3.2.Credentials and Technological Change

The lifelong education policy solution for the increasing job insecurity aimed to cope with the migration to a service economy and the effects of technological change. Workplace computerization for the industries that were not offshored in their production infrastructure caused a displacement of workers who watched their jobs replaced by technology (computers) (Autor & Dorn, 2013; Howell, 1999; Reshef, 2013). The job destruction in the manufacturing industry forced workers to acquire new skills to reallocate themselves to other industries (Hobor, 2013; Weiler, 2000) or fall into chronic unemployment with its social and economic consequences (Gangl, 2006; Young, 2012). That is consistent with management scholarship response to the emergence of new understandings of organizational structure and the implied changes in career development (M. B. Arthur & Rousseau, 1996; Baruch, 2006)

The interaction between the deindustrialization process and the migration to the service economy led to a new configuration of the labor market, referred to as job market polarization. This configuration is multidimensional and considers elements related to wage distribution, quality of employment, and the demand for occupations (Autor et al., 2008; Goos & Manning, 2007; Lindley & Machin, 2014). The shrinking of middle-complexity jobs characterizes this depiction of the evolution of the labor market occupational structure in favor of low- and high-complexity jobs (Kalleberg, 2012). In simple terms, the job market polarization has led to a disappearance of occupations in

the middle of skill/wage distribution and produced a scenario where mainstream and secondary markets are consistent with the ideas of the dual market theory (Reich et al., 1973).

The vision of a dual market theory has been applied to more recent research as a segmentation phenomenon (Glass, 2008; Poggi & Silber, 2010). The mainstream market in this frame will be assimilated into the white-collar job market, while the secondary market will be understood as the blue-collar job market. In this case, credential fulfills a role as a gatekeeper for entering the white-collar job market, requiring higher education degrees to participate and compete. High-quality jobs (wages-skill-employment) will be placed in the mainstream market, pushing workers to acquire higher education credentials to have access and gain some socioeconomic status related to the occupations belonging to that market.

The complete scenario until this point is that during the last forty years, the employment-occupational structure of the labor market has evolved, changing the demand for skills and abilities. This change has promoted a structure that has favored high-skilled workers as described by the skill-biased technological change (Marquis et al., 2014) and redefined the nature of occupations as the routine-based technological change proposed (X. Wang, 2020). This process has also modified the meanings and representations associated with credentials, its ability to represent skills, and its use as a coordination tool for labor and educational markets.

Section 4. Credentials during the Fourth Industrial Revolution

4.1. Knowledge-to-Digital-Economy Transition

The previous migration to a service economy from an industry-based economy fueled the narratives on knowledge as a source of value creation. Knowledge was proposed as the key to building competitive advantages across industries and national

economies (Sydler et al., 2014; Viedma Marti, 2004). That emphasis on knowledge creation and management enhanced the need for more training and education in the workforce, seeing workers as key players in the production process by contributing to building intangible resources for the organization (Leslie. A & Weatherly, 2003). That was the primary trend until the arrival of the digital economy.

While the intellectual capital effect on value development was central to the knowledge economy, the digital economy focuses on how technology enables process optimization. Assuming the transition from knowledge-based applications to optimization-process solutions, the change in value-creation source also affects the factor's relative prices. In other words, the knowledge-to-digital-economy growth will transfer a portion of the value of the marginal contribution of labor to technological solutions depreciating human capital (Didier, 2021a). Consequently, organizations' behavior had to change and focus their competitive strategies on digital transformation.

Digital transformation describes how organizations design and execute their internal process. Those changes include digitalization, computerization, and even automation. Such developments aim to optimize organizations' value chains and become a measure to control costs and increase efficiency levels (Hess et al., 2019). As an optimization process, digital transformation pushes organizations to improve their competitive advantages and share their reference markets (Berman, 2012) through the inclusion of digital technologies such as social media, mobile access, and business analytics to enhance the customer experience (Bounfour, 2016; Singh & Hess, 2017). Digital transformation also implies restructuring the internal production chain by placing resources on how companies identify and answer customer needs, creating fidelity or differentiation from their competency (Piccinini et al., 2015).

Since the value creation in the digital economy has moved from workers' knowledge to production optimization, the knowledge-to-digital-economy transition appears in two directions: the transformation of the manufacturing industry production process by the inclusion of disruptive technologies (i.e., industry 4.0 (Fuchs, 2020; Valencia et al., 2019)), and a shift in the demand towards digital-related skills (Hirsch-Kreinsen, 2016). That has been the critical node of WEF's reskilling revolution, where the future of jobs appears to be tensioned by the technological dependence on occupations (World Economic Forum, 2020a; 2018). That perspective is also shared by other international organizations (i.e., UNIDO (2019), ILO (2020)), stressing the need for labor and educational policies to keep pace with technological transformations to ensure future sustainability.

4.2.Digital Skills, Credentials, and Labor Relations

Even considering the transformation of manufacturing as the critical issue of the 4IR, its impact will differ according to the prior industrialization and installed capacity (Alberto & Escamilla, 2018; Alquicira et al., 2020; Singhal, 2020; Sung, 2018). In the labor realm, the challenge of the knowledge-to-digital transition is covered by the availability of skills in the workforce to keep the pace of technological change and grant the use of the window of opportunity brought by industrial revolutions (Perez, 2004; Pérez, 2001). However, the demand for digital skills is pushed by the attractiveness of digital economy companies and the opportunity to get the benefits of scale economies and fewer interactions in implementing supply chains.

From an economic perspective, the substitution-complementarity relationship between labor and technology will demand employment and skill in times of technological change. Past evidence on workplace computerization has shown that some occupations were downgraded (deskilling) in complexity by replacing routine

tasks with computer processes (partial substitution). In the frame of the 4IR, there is no agreement on the substitution-complementary relationship between labor and technology (Acemoglu & Restrepo, 2020; Scarpetta, 2019; Spencer & Slater, 2020). Some argue that automation could begin to produce job downgrading in the white-collar job market using artificial intelligence and algorithms to replace human decision-making (i.e., budgeting and personnel selection (Chien & Chen, 2008; Kushtina et al., 2009)).

This uncertain substitution-complementary relationship between labor and technology increases the pressure on education and labor market coordination. Human capital acquired through higher education could be replaced by technology, increasing the relevance of mastering the interactions in digital environments. The demand for digital skills would be related then by workforce upskilling in the case of people with higher education credentials and reskilling for those workers who participate in the blue-collar job market and seek to be reallocated in industries and economic activities with better outcomes in terms of employment, job quality, and wages.

Therefore, the problem of technological change returns to educational credentials. How can people signal the possession of digital skills? Emergent technologies have started to provide a solution using micro-credentials and digital badges (D. Gibson et al., 2015; Shields & Chugh, 2017; West & Lockley, 2016). Online educational experiences have increased students' and workers' access to new knowledge, usually not affordable in their countries. Different e-learning platforms and suppliers have emerged to cover the overdemand for the formation and working skills faster than the regulations, as with digital economy companies (Howcroft & Bergvall-Kåreborn, 2019; Lüthje, 2019).

The nature of that kinds of credentials is not necessarily grounded or supported by national institutions, which increases the variety of certifications present in the labor

market but with an uncertain valuation from industries and employers (Banks & Meinert, 2016; Kopp & Ebner, 2017; X. Li et al., 2015). The variety, industry-specificity, and lack of institutional support on the elaboration and regulations regarding those kinds of credentials provide a complex scenario for labor market adaptation to the vision intended in the reskilling revolution agenda.

Section 5. Policy Challenges for Credentials

Diverse economic development processes have affected the nature and valuation of educational credentials: technological change, educational systems expansion, deindustrialization, and, later, the emergence of non-formal learning opportunities through digital platforms. Combining those phenomena has crafted a wicked problem for human capital accumulation, where educational experience has started to be displaced as the primary strategy to signal the relative level of workers' skills by non-institutionalized mechanisms of skill/productivity signaling.

The critical element of the current situation is the uncertainty of the possible effects of 4IR on labor market behavior. Most of the scholarship on this issue is based on speculative methods about what the market will demand in the future, the configuration of new labor relations (de Ruyter et al., 2019), and an emphasis on digital skills for supporting the change in the production process (World Economic Forum & The Boston Consulting Group, 2018). As Reddy (2020) suggests, automation anxiety has taken a large part of the agenda, basing the analysis on the future of work in the substitution relationship between technology and labor. Public discourses tackle the issue by two means: pushing for adapting workforce capabilities based on technologically-biased labor demand (emphasizing on non-perfect complementary-substitution labor-technology relationship) (Huysman, 2020; Willcocks, 2020) and the creation of social security strategies to mitigate the effects on employment (Bruun &

Duka, 2018). While both discourses are relevant to policymaking, I will only focus on the first due to their direct relationship with educational credentials.

A policy perspective on the challenges of the 4IR and the future of work narratives for workforce development will bring three critical questions for public affairs scholarship: First, which is the magnitude of the effects expected for specific national economies? Second, what evidence is available for each country related to labor and educational policies to guide the debate on workforce capabilities adaptation? Moreover, what is the institutional background for coordinating labor and educational markets?

While the narratives on technological change tend to be overarching and globalized, policy responses are at national and local government levels. Even the estimates provided by the world economic forum show that the economic growth by the 4IR will be absorbed mostly by developed nations and some emergent economies (World Economic Forum, 2021). In this sense, national governments should address the specificities of the technological challenge by understanding that the expected effects could not be the same across countries, looking for a nationally grounded policy rather than one more globalized one. For example, the analysis of future jobs shall consider technological adoption levels, the relevance of some industries in the national economy, managerial practices, and labor regulations. Without those elements, workforce policies could be ineffective in addressing the economic growth possibilities and the threats to social welfare. Credentials should be analyzed and designed to interact with industry-specificities and possible economic development scenarios.

The second question points to policy learning as a strategy for crafting “new strategies” to cope with technological changes. The availability of evidence regarding the evolution of active labor market policies and the implementation of educational policies affecting workforce capabilities is the key to future policy design. If prior

policies to cope with technological unemployment or deindustrialization-based unemployment failed recently, those policy instruments should be redesigned if some success is attempted from its implementation. Governments addressing skill shortages in the national economy should consider how training policies have worked in labor market outcomes and how those impacts could be translated to this new scenario with deregulated training providers. The same goes for upskilling strategies based in traditional education institutions, including the educational curriculum, the emergent demands of the labor market, and the usefulness of vocational training at a secondary education level. Educational credentials and their ability to represent workers' skills play a critical role in training and educational policies and inform concisely how the labor market reacts to past workforce development policies.

The third question links the specific characteristics of national economies with a policy perspective for workforce development. Educational credentials are supported by institutional arrangements that allow them to serve as coordination devices between labor and education markets. The emergence of new skill sets demands and ways to acquire them also stresses that the institutional frame supports credential-mediated coordination. Policy challenges from this scenario come from legal regulations, quality of training provision, and transactional value of training-based credentials. Those elements will interact with the current demand of industries and economic activities and deal with the institutions and value of previous educational credentials.

Suppose governments seek to develop a policy response to the challenges of the future of work and the 4IR. In that case, preliminary questions should be addressed to decrease decision-makers' uncertainty regarding human capital accumulation for workers and the usefulness of credentials to reduce information asymmetries for employers.

FRAMING TECHNOLOGICAL CHANGE INTO TRANSITIONAL LOGIC

Section 1. Introduction

How can governments cope with the challenges of the current wave of technological change? That seems to be one of the critical questions on advancing the fourth industrial revolution (4IR) narrative regarding the possibilities of economic growth, increased economic efficiency, and even higher levels of social welfare (Perez & Schäfe, 2021; Schwab & Davis, 2018). While the combination of technologies included in the 4IR is broad and could have a differential impact on diverse economy parcels, there is an assumption that the overall effect will alter how companies organize the production process, affecting the balance between economic factors and industries' performance. For example, the combination of hardware (sensors) and software (computer programs and algorithms) technologies is enabling the advance of "smart factories" with higher levels of automation (Cimini et al., 2017; Shao et al., 2021; Tao et al., 2021), optimizing the allocation of resource in goods production and impacting in the labor demand for manufacturing industries.

However, the focus on manufacturing industries and the gain of economic efficiency is only one side of the storytelling regarding the 4IR. There is a second layer related to the ability of companies and even national economies to take up the benefits of technological change (World Economic Forum & The Boston Consulting Group, 2018). This layer is based on the labor side of the production function, or specifically, on the ability of the available workforce to catch up with the emergent demands for skills that enable the technology adoption process. In that sense, the advances of technological

change associated with the 4IR forecast a complex layout for obtaining the benefits of the "improved" economic efficiency of production factors and managing the changing demand for a skilled workforce.

The labor layer of the technological change problem leads to questions about how technology has influenced the evolution of labor market structure and operation. Economic agents face the promises and projections regarding the effects of the 4IR through the lens of their previous historical experience, reasoning about the changes in the labor supply and demand from the learnings of the previous industrial revolution. Those learnings include a parceled understanding of how technology biased the labor demand in favor of the highly-educated population (Katz & Autor, 1999), displaced semi-skilled workforce by substituting the routinized task by technology (i.e., computers) (Goos et al., 2014), and crafted an uncertain scenario for workers forcing them to acquire more significant amounts of human capital in a faster fashion and with higher frequency than in the time prior to the third industrial revolution (OECD, 2019; Watts & Sultana, 2004). The same elements intermix with managerial and organizational knowledge regarding the evolution of labor relations and career development (M. B. Arthur & Rousseau, 1996), organizational structures (Bergenholtz, 2011; Maravelias, 2003), and the need for timely adaptation to remain competitive or sustainable through quality management models (Ayad, 2010; G. Chang, 2009). Nevertheless, the intermix between the different levels of analysis and disciplinary understanding of each phenomenon, amidst the geographical and temporal differences, creates a challenging scenario to decode the nature of the process of the current wave of technological change, the possible impacts on the economy, and the policy response required.

In this chapter, I propose an empirically-driven theoretical model on how to frame the technological change problem associated with the 4IR from a policy perspective

based on a unified understanding of the antecedents, the current situation, the forecasted scenarios, and the policy tools available for addressing the social consequences in the labor layer. The rest of the chapter is organized as follows: section 2 discusses the essential elements regarding the mechanisms and operation of policy learning and diffusion from a comparative policy perspective. Section 3 presents a transitional model of workforce adaptation and its conceptualization, and section 4 presents a research perspective on what policymakers should know to design and implement policies to smooth the transition process.

Section 2. A Policy Learning and Diffusion Perspectives

One prominent problem policymakers face regarding technological change agendas is that most of the reflection and research regarding the third and fourth industrial revolutions has been detached from the policy perspective. At the same time, economics has been focused on the substitution-complementarity relationship between technology and labor and its effects on the labor market (Gomes, 2019; Yuhong & Xiahai, 2020), the sociological and managerial focus has been placed on the evolution of the socio-technical systems and how to facilitate the process of organizational adaptation (Cooper & Kaplinsky, 2005; Liu & Grusky, 2013). Although there are shared concerns regarding how technologies associated with the 4IR could affect employment across international organizations (PNUD, 2019), the desirable policy response remains unclear.

Policy systems require advocacy coalitions, epistemic communities, and policy entrepreneurs to policy communities (Knaggård, 2015; Moyson et al., 2017; Mukherjee & Howlett, 2015) intermediation between the social demand/policy issue and the possible pathway to solving that issue. As most policy process theories problematize, one relevant condition for policy formulation is the availability of

information or communicational mechanisms to frame a social problem in a way the policy system can decode. Still, given the dispersed and disciplinary focus of evidence, it is difficult for policy systems to decode what is the real problem (if there is any), what are its characteristics, and how to understand the long stream of causes and consequences that are forecasted as the possible impacts of the 4IR.

Since a policy response requires awareness of the problem's nature and the policy alternatives' characteristics, a rational approach can be developed from the optics of policy learning. Policy learning allows covering diverse concepts and theories regarding how governments learn from others and, through that process, improves the efficiency and efficacy of their policies (Maggetti & Gilardi, 2015; Peel & Lloyd, 2008). This learning process could undertake diverse pathways, such as the focus on policy diffusion through ideological components of the policy (Oakley, 2009; Sugiyama, 2008) or the focus on the availability of evidence for policy transfer (Schmitt, 2012).

Either focusing on the principles or orientations to public values and their consequences for policymaking or in a more evidence-centered policy process, the globalized narratives of technological change dynamics and availability of information allow us to focus on what can be learned from past processes of technological change and which policy tools could help be used in the new context. In this sense, the idea of policy transfer appears to help lead the process of developing a policy response based on adopting policy ideas from one jurisdiction to another (i.e., country, state, county, municipality) (Benson & Jordan, 2011; Dolowitz & Marsh, 1996; Evans & Davies, 1999). While there are distinctions regarding the nature and learning mechanisms across the specialized literature (Meseguer, 2005; Mossberger & Wolman, 2003), there is an agreement on the complexity involved in adopting foreign ideas to the policy system. That is the case of "soft policies" or "hard policies," differentiating the information about ideas, concepts, and norms from institutional structures,

policies, programs, projects, policy instruments, and their implementation process (Stone, 2004).

"Reskilling revolution" and *"future of work agendas"* associated with the 4IR operate as an intermixing between "soft" and "hard" policies, assuming the effects of the third industrial revolution on labor market structure and projecting some policy instruments (i.e., training programs, skill-upgrading, educational expansion). However, the same policy instruments (active labor market policies) have shown diverse impacts concerning their targeted outcomes based on institutional factors and economic systems (Almeida & Aterido, 2015; Bergemann & van den Berg, 2008; Caliendo et al., 2011; López Moureló & Escudero, 2017). In the case of Latin American countries, the evidence regarding the operation and impact of the intended policy tools is diffuse, holding different quality characteristics in the analysis (Didier & Cox, 2012; Ramirez-Anormaliza et al., 2017; Telleri et al., 2013; Villar et al., 2013).

Therefore, the development of a policy model that allows to organize and systematize the challenges of the 4IR and provides alternatives for policy learning and transfer requires (a) establishing the stylized facts of the 3IR technological adaptation process, (b) facilitating the understanding of the current scenario (national and international levels), (c) contextualizing the forecasted problems to a national economy setting, and (d) allowing to problematize the policy strategy and instrument design.

Section 3. The Transitional Model for Workforce Adaptation

The first element required to address the challenges of the 4IR is to understand the technological change as a multilayered process that summarizes the interrelation between technological progress, educational systems, and labor market evolution.

While disciplinary research has pointed to specific time frames and emergent relationships between the layers, developing a broad understanding of the complete process requires a high degree of awareness of how the prior wave of technological change set a scenario for the current labor market structure, and how from those conditions the future imaginaries arise as a logical or feasible condition for labor development. Those connections between past experiences, the current situation, and the forecasted development of the relationship between technology, education, and labor would be the key to policy development.

That temporal-linked structure for the technological change process will have three critical assumptions that allow for narrowing down the phenomenon's dimensionality. First of all, the frame of the 4IR includes several technologies that are not part of the concern of international organizations regarding the future of jobs (Grimshaw, 2020), like in the case of bioprocesses-related technologies (i.e., bio-tech). Instead, the focus has been placed on how digital technologies and the advance of the digital economy would produce a significant event of labor market restructuring (OECD, 2016; PNUD, 2019). Second, the forecast on the future of jobs and how digital-related technologies would affect the labor market assumes a homogeneous pattern for technological adoption and access to new technologies. For example, while the WEF differentiates between countries with more significant potential for increasing their economic efficiency and overall productivity (World Economic Forum, 2021), their analysis tends to focus on the most prominent world economies and treat their labor markets (World Economic Forum & The Boston Consulting Group, 2018) equivalently. Third, the envisioned transitions tend to homogenize the job contents between job families and occupations (World Economic Forum, 2020b), disregarding the natural differences produced by industry organizations and national economies dynamics.

Since it is desirable for policy efficiency and efficacy to use the information available to design and implement policy tools, I propose a transitional model for workforce adaptation (figure 1), which allows the inclusion of the historical experience of economic agents, the diversity on the current labor market structure across countries, and how those elements could affect the mainstream approaches to the future of jobs and work. I include those elements to problematize the policy response, considering how those elements would influence the effectiveness and suitability of policy instruments.

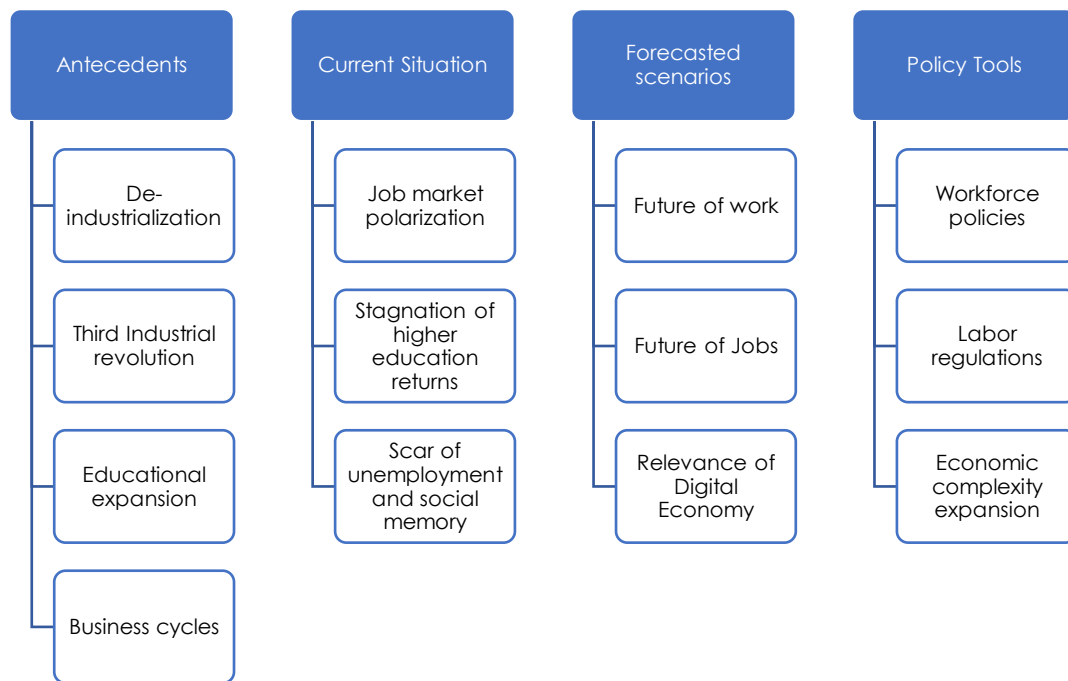


Figure 1. Transitional Model for Workforce Adaptation

3.1 Antecedents

Despite the theoretical controversies regarding how to frame the technological change process across disciplines, there is an agreement that the inclusion of computers and, later, the development of ICTs greatly impacted labor market

organization and dynamics. While those effects have persisted until the present, empirical research has associated the restructuring process of the labor market with different socio-technical and economic processes that have co-occurred since the early seventies. I refer to that combination of elements as the narratives of technological change. Those intermixed processes produced the current scenario for the economic organization of national economies and labor markets.

The mentioned narratives include four major processes: the deindustrialization of developed economies, workplace computerization and increasing relevance of ICTs, the expansion of tertiary education enrollment, and the differential response to business cycles. While across countries, there are notorious differences in how those the elements included in those narratives occurred (i.e., impact, institutional response, the timing of reforms), the literature has established a mainstream approach to those phenomena based on developed economies' experience (i.e., the US, European countries, Australia, Canada). Thus, the elements included in those narratives should be individualized and described for transparency in policy learning and transfer, especially regarding the assumptions for policy design.

I divide the analysis into the economic process, policy environment, and labor market adaptation layers (see figure 2). In the *economic process*, I distinguish between the deindustrialization process of developed economies and the direct effects of technological change. The deindustrialization process covers the offshoring strategy of companies that sought to decrease their production cost by moving their factories and manufacturing process to countries with a relatively lower cost of human capital (Harrison & Bluestone, 1990), followed by the trend to outsource some support processes internationally as the call centers or IT support (Russell & Thite, 2008). In the case of technological change, it includes the penetration of workplace

computerization and the adoption of ICTs technologies as relevant elements of the production process (Howell, 1999; Knutsson, 1986).

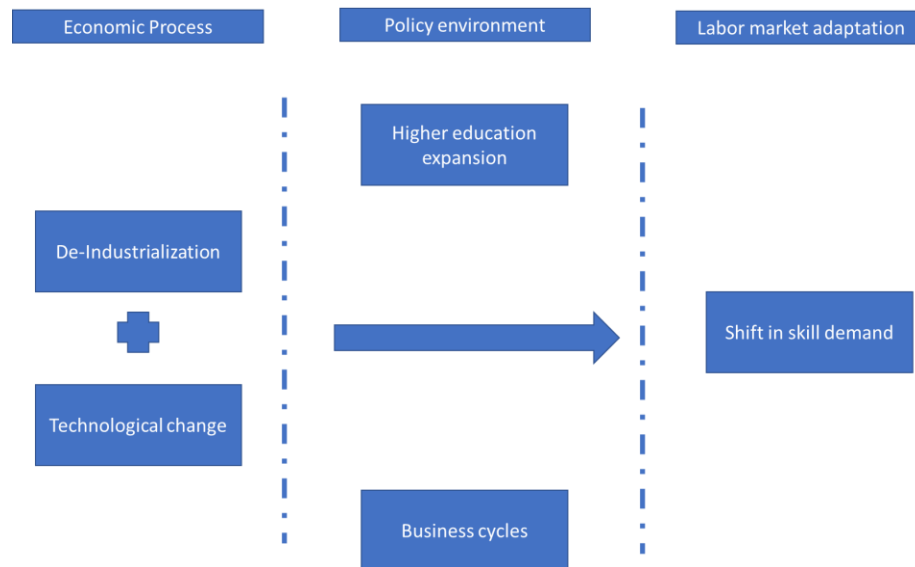


Figure 2. Antecedents from Previous Technological Change Wave

Deindustrialization and technological change significantly affected the labor market structure, changing the demand for occupations and, consequently, the human capital pricing along the production process. The decrease in the share and relevance of manufacturing industries led to accelerated human capital depreciation (de Grip, 2006; Kredler, 2014), especially regarding the industry and company-specific levels. Simultaneously, the inclusion of disruptive technologies altered the work environment, job contents, and demands, replacing monotonous and repetitive tasks with automated solutions (Goos et al., 2014). In the long run, combining both processes led to a change in the skill demand, favoring those with higher levels of skill represented in their educational attainment (Howell & Wieler, 1998; Katz & Autor, 1999).

The policy environment layer operates as contextual elements that fueled and accelerated the labor market change process. Those elements interacted in the form

of adaptation to the new conditions of the economic process layer, increasing the pressure for higher levels of human capital accumulation to access a job given the disappearance of traditional jobs in the manufacturing and related industries. On the one hand, the expansion of higher education allowed individuals to shelter themselves from the negative externalities of technological change through skill upgrading, aiming for achieving occupational mobility and looking for skilled occupations (Montresor, 2019). On the other hand, the logic of the business cycles introduces the differential reaction of business owners when coping with economic crisis (Jaimovich & Siu, 2020), which includes the reallocation of capital through different industries leading to jobless recoveries, where the economic activity retakes their path of growing but not the employment (Cortes et al., 2017).

Finally, the layer of labor market adaptation covers the consequence observed as wage polarization and the change in the relative value of human capital (Acemoglu & Autor, 2011; Parro, 2019). Because of the restructuring process in the labor demand due to technological change and the downturn of manufacturing activity, employers changed their preferences regarding the skill development of their employees, moving individuals to acquire higher levels of human capital to access better jobs (i.e., higher wages, high quality of labor relations) (Kalleberg, 2011; Kalleberg et al., 2000). In this layer, it is possible to cluster the neoclassical economics hypotheses based on how the technological change affected employers' preferences (skill-biased technological change), redefined jobs' contents (routine-biased technological change) and derived in a polarization of the job market (job polarization).

3.2 Overview of Current Challenges

In the literature that forecasts the challenges regarding the 4IR, the assumptions, and diagnostic of the current scenario are firmly grounded on how the stylized facts labeled as antecedents reshaped the economic dynamics and the behavior of economic agents (Scarpetta, 2019; Schiølin, 2020). Those elements appear compelling for policymakers given the threats and challenges of the new wave of technological change and the alternative paths available to engage economic growth and social welfare opportunities. Still, as was mentioned previously, the configurations reached by labor market adaptation to the prior process of technological change have shown significant cross-country differences. Those differences consider the process of job polarization, the stagnation of higher education returns, and the scar of unemployment and the associated social memory.

The problem of job market polarization has been addressed in diverse ways in economic and sociology literature, including a large chain of interrelated phenomena such as wage polarization, employment polarization, and job market polarization (Bárány & Siegel, 2020; Green & Sand, 2015; Poggi & Silber, 2010). On a brief overview, job market polarization implies a change in the labor market structure where the market appears segmented or behaves as a dual market. That dual or segmented structure differentiates a mainstream market (high wages, high-quality labor relations, high-complexity jobs) from the secondary market (low wages, low-quality labor relations, low complexity jobs).

That understanding of the polarized structure of the job market assumes that through the longstanding process of the prior wave of technological change, at an aggregated level, the share of middle-income jobs decreased in favor of the other two tails of the job-income distribution (Buyst et al., 2018). From here, we will have two perspectives: the market-based perspective and the workers-based perspective. The occupational market perspective will describe the job market polarization as a

restructuring process of the occupational structure of the labor market, where semi-skilled occupations (ISCO major groups 04-08) decreased their share, being replaced by skilled (ISCO major groups 01-03) and unskilled occupations (ISCO major group 09) (Sparreboom & Tarvid, 2016). The workers-based perspective will consider that the polarization results from the sum of individuals' strategies to cope with the changes in the labor demand, being summarized on the axis of occupational upgrading to deskilling (Ertürk, 2021).

Regardless of the perspective, the phenomenon of job market polarization is strongly linked to the conditions of higher education expansion and the business cycles. The migration to a service economy fueled by deindustrialization made individuals choose to acquire higher levels of educational attainment to ensure their employability and better perspectives on wages (A. Brown et al., 2012; Tholen, 2013). Still, higher education credentials showed a limit on their ability to represent higher skill endowments, placing pressure on alternatives of crediting the possession of skills demanded by service-economy industries (Crossman & Clarke, 2010; Pillai et al., 2012). This uncertain scenario for higher education, especially for advanced degrees, has been characterized by the stagnation of the returns to tertiary education investment and the difficulties offered by the education-occupation mismatch (Halaby, 1994; Neumann et al., 2009; Sloane, 2014).

Despite the overfocus on the change in the production process during the third industrial revolution from neo-classical economics, unemployment, and especially technological unemployment, represents a significant concern for policymaking due to the multidimensionality of its effects (Schmelzer, 2011; Young, 2012). However, the occupational upgrading to deskilling axis offers an alternative approach to the polarization problem connected to technological unemployment. The deskilling pathway, led by job destruction and job content redefinition (Acemoglu & Restrepo,

2020), also produced a social memory or a social representation of how some social groups or even regions could adapt and how others could not. For example, in the case of the US and Germany, some regions presented significant problems adapting to the new scenario crafted by the third industrial revolution, showing persistent patterns of unemployment and low economic performance (compared to other states or regions) (Hobor, 2013; Maillat & Lecoq, 1992; Mehic, 2018; Weiler, 2000).

Regional and social differences in how countries adapted to technological change appear relevant in defining the evolution and consequences of the job polarization process, including timing and institutional effects. For example, Adermon and Gustavsson (2015) analyzed Sweden's polarization process between 1975-2005, finding that the outcome of a polarized job market structure appeared since the nineties, without any sign of the process in the seventies and the eighties. In their analysis comparing four European countries, Oesch and Piccino (2019) found that job polarization was not inevitable due to technological change. They argue that the absence of a polarized dynamic in the labor markets of Germany, Spain, and Sweden, compared to the polarization of the UK market, is explained by the availability of a highly skilled workforce (universal higher education policies) and by the offshoring of low-quality jobs. Oesch and Menes (2011) also place as a moderator to job polarization the existence of wage-setting institutions that could smooth the changes in the wage distribution given the change in the occupational structure of the job market.

In the long run, while institutions, access to technology, and human capital stocks in the labor market can play a role, a single narrative on how technological change led to a polarized job market seems insufficient to anchor the dose-response relationship between both elements. The agents' response to new technologies appears to be related to other factors that can trigger labor-technology substitution that is not homogeneous across developed countries (Murphy & Oesch, 2018). In the review

developed by Martins-Neto et al. (2021), it is possible to find consistent evidence that in developing economies, there has been a similar behavior to the described by the skill-biased technological change, but not deriving in polarized labor markets. In their argument, they consider different sources of explanations clustered in the differences in the economic structures (ex-ante wage distribution and industrial organization), technological adoption dynamics, and the interactions with other economies (global value chains).

The differences depicted by Martins-neto et al. (2021) bring into the discussion an essential element for translating the narratives of technological change from developed to developing economies setting: the globalization process did not produce the same effects across countries. While the antecedents covered the role of offshoring strategies, the relationship was directional: from developed economies to developing economies. However, not all developing countries received foreign investment from that strategy, leading to differential industrialization from countries in Asia compared to the situation of Latin American countries during the same period (Didier & Perez Comisso, 2023). Accordingly, although the focus on global value chains is relevant for the analysis, the complete role of the industry's installed capacity tends to be overlooked. Most of the literature on job polarization assumes that every country has had and currently has the possibility of developing offshoring strategies for their industries and jobs. That is a highly questionable assumption that appears detached from the historical experience of developing economies worldwide.

In synthesis, a general and homogeneous narrative on the causal chain between technological change antecedents and the current situation appears insufficient or flawed, especially as the starting point for policy design. Consequently, policy development in this context should avoid the technological determinism in the neoclassical approach to technological change and include the idiosyncratic behavior

of national economies on a sociohistorical basis (Nolan & Slater, 2010). Thus, the inputs or the base levels for critical variables connecting labor market behavior and the challenges of the 4IR should be explored in terms of how the labor process could present variabilities to enhance the possible effectiveness of policy tools.

3.3 Forecasted Scenarios

As was noted previously, the technologies clustered in the frame of the 4IR are diverse and non-necessarily based on the evolution of the digital economy and its requirements (i.e., bioprocesses). Still, the angle of international organizations assumes that the most significant impact of 4IR on labor market structure and operation will come from digital technologies (Grimshaw, 2020), especially regarding the idea of automation. Thus, the third axis of the Transitional Model for workforce adaptation includes the tension between imaginaries and agendas of "*the future of work*" and "*the future of jobs*" related to automation in the context of the increasing relevance of the digital economy.

Disruptive technologies at any stage in the history of industrial revolutions allow the optimization of production processes or create possibilities regarding new goods and market solutions for emergent social demands. The idea of automation is not new, and it has been present during the trajectories of the industrial revolutions, from energy to machines, from machines to assembly lines, from assembly lines to process optimization, and from optimization process to the representation of the "smart factories" (Cimini et al., 2017; Peralta & Soltero, 2020; Shao et al., 2021). Still, in the current framing for the 4IR, the public perspective on the issue of automation is that it could re-edit part of the experience described as the antecedents of the model, advancing over the remnants of manufacturing industries in developed countries

(OECD, 2016) but more importantly in countries with a more significant share of manufacturing production (World Economic Forum, 2021).

In this regard, policymakers face an opaque problem formulation that mixes how technology changes the working environment or working conditions (future of work) and how technology changes the nature and demand of some occupations. In the dimension of the future of work, the approach considers the broad range of alternatives to adapt to the advance of the digital economy (including here gig and platform economies (Glavin, 2020; Howcroft & Bergvall-Kåreborn, 2019; Spreitzer et al., 2017)), including the redefinition of skills across the jobs given the digital environment. This vision also allows the inclusion of a definition of skills required in the workforce to engage the economic benefits of the 4IR (World Economic Forum, 2020b; 2018). On the other hand, the macro-level perspective of the employment process will lead to the question about the future demand for some occupations that are likely to be subject to redefinition on their contents given the substitution of some tasks and their related skills by technological solutions (World Economic Forum, 2019). In this sense, the future of work is a compelling frame for managers and workers, allowing them to navigate their employability processes. In contrast, the idea of the future of jobs allows policymakers, governments, and large companies to define strategies to cope with the forecasted problem of skill shortage and workforce availability.

When this last focus on the future of jobs and the employment problem is introduced into the policymaking process, the lessons from the prior process of technological change gain relevance. As described in the presentation of the antecedent's axis of the transitional model of workforce adaptation, the longstanding process of capital and labor reallocation across industries produced a cleavage for interpreting the socioeconomic consequences of modifying the technology-labor

substitution-complementarity relationship. Observing the past trends on job destruction and job creation has allowed us to forecast scenarios where automation (cyber-physical systems, smart factories, sensors) and digitalization (data processing and data-driven decision-making) lead to a decrease in the net labor demand for some occupations (Huang & Rust, 2018; Spencer & Slater, 2020; World Bank, 2019).

However, the envisioned impacts are far from homogeneous and global-shaped and would be defined by the national economic structure and the current configuration of the occupational structure of the labor market. Table 1 summarizes the differential impact of automation on different economic activities, considering the clustering of the International Standard Industrial Classification of all economic activities (ISIC) (United Nations, 2022b).

Table 1. Theoretical Impacts of Automation on Workforce and Skill Demand by Economic Activities

<i>Economic Cluster</i>	<i>activity</i>	<i>Primary Technological dimension (artifacts)</i>	<i>Consequence</i>	<i>Skills / Workforce targeted</i>
Agriculture		Technification and use of machinery	Change in the requirement of the unskilled workforce.	Unskilled
Manufacturing		Smart factories (automation, sensors, integrated production)	Decrease in demand for semi-skilled and unskilled workforce	Routinized tasks (specific human capital)

						Semi-skilled and unskilled workforce
Other activities	Industry	Automation along the value chain and decision making	Change in the process of decision-making with improvements in the data processing			Routinized task-related skills, and Abstract service skills
Service activities		Data processing (Artificial Intelligence, cloud computing, Internet of Things)	Digitalization of some features of the decision-making process and customer-support procedures			Abstract and Semi-skilled and skilled occupations

Following the logic of table 1, the possibility of automation for every occupation in the job market will depend on the economic activity demand for labor and the propensity for technological adoption of the specific industries. Since not every digital-related technology will be available in every country (price, distribution, infrastructure, commerce sanctions), any analysis suitable for policy design should be grounded in the conditions for technological adoption allowed by the institutional setting and countries' idiosyncratic industrial organization.

3.4 Policy Instruments

From this point, decoupling the concepts of the *future of work* and the *future of jobs* allows forecasting the three main pitfalls for workforce policies that should be addressed jointly: the evolving nature of labor relations and its normative framework (future of work) with its related questions regarding workforce skills allocation across the labor market, the availability of providing mechanisms for the skills required, and the strategies to accompany the process of economic transition between the logics of the knowledge economy to the digital economy.

The notion of the *future of work* comes with several questions regarding how jobs/occupations would adapt to the new conditions of the production process. From the competencies announced to gain relevance during the technology adoption process to the new forms of labor relations, it is possible to observe a complex layout for current and future economic agents' decision-making. For example, during the past acute technological change, abstract cognitive and service skills gained value over the depreciation of routinized-skills demands (Autor et al., 2003). The market signals for employers and workers were somewhat clear: employers changed their preference towards highly educated workers to ensure higher degrees of adaptability in the changing environment for their companies, while workers updated their preferences for human capital investment to get the competencies now demanded. In the current context, digital technologies associated with the 4IR show a ubiquitous nature, with greater interactivity levels, altering spatial and temporal dimensions of the job experience (Baskerville et al., 2020; Carillo et al., 2017). In this sense, digital technologies have greater pervasiveness given that their availability is not constrained to the work environment, altering how their related skills could be learned and the level of the workers' familiarity with those technologies.

One additional issue appears when a platform or gig economy is included in the equation for a policy response. During the twentieth century, governments across

advanced to social security, establishing floors and benchmarked policy to scaffold some levels of social well-being (Frota, 2008; Min et al., 2019; Ryder, 2015), advancing to establishing long-term goals as the Millenium Objectives and later the Sustainable development goals (Sachs, 2012; United Nations, 2022c). However, the platform economy is redefining the roles of employees and employers, disintegrating the margins of social protection by alternating the definition of employees or workers to contractors (Glavin, 2020; Josserand & Kaine, 2019; Kaine & Josserand, 2019). From here, governments have to deal with the inability to generate effective strategies to regulate and tax digital platforms (Pulkka, 2017; Turina, 2020; Yuan et al., 2021), with the advance in the precariousness of labor relations (and income) given the shift in between employees to contractors (Cherry, 2016; Sutherland et al., 2020) and ensuring the sustainability of social protection institutions covering unemployment, occupational health, and pensions systems.

Regarding the *future of jobs*, the key to interpreting the concerns of international organizations and governments is understanding the dynamics of skill formation and employment cycles during economic transformation processes. The forecasting regarding the future of jobs combines the job creation/destruction rates with the qualitative identification of which jobs/occupations would tend to shrink across time (World Economic Forum, 2020b; 2018). Since the skills involved and the nature of technological change differ from the 3IR, the institutional arrangements that allow to take up the benefits would also differ. In this sense, strategies based on human capital would face diverse environments, which include the current human capital endowment of the workforce (with significant differences across countries), the dynamics of access to post-secondary education (i.e., educational policies, perceived quality of formation, public-private provision, funding), the availability of non-traditional mechanism to acquire formation and training (*ed techs*), and the robustness of labor institutions and

workforce policies (i.e., certifications, occupational licensing), among others. Most of those features were produced or developed to their current stage during the third industrial revolution, with their assumptions and rationale applied to the education-labor relationship.

Following the framing of the 4IR and the need for workforce up-skilling/reskilling, workforce policy must deal with the abovementioned elements as part of the policy environment. In this regard, the government will find an idiosyncratic context for policy design and implementation for each country or labor market. For example, the provision mechanisms for post-secondary education determined the differential evolution of the labor market to a polarized occupational structure. Universal policies in higher education allowed more significant segments of the workforce to access the high-skilled job market, compared to countries with more restricted access (relying on a market solution) (Oesch & Piccitto, 2019). Even across developing countries, access to higher education is a matter of discussion regarding its impact, given the different institutional mechanisms undertaken for their expansion (Chiroleu & Marquina, 2017; Ferreyra et al., 2017). The same goes for active labor market policies across European countries, which, fueled by the discourse of the knowledge economy and the migration to the service economy, experienced a robust institutional development framed in the idea of lifelong education policies combining training, certifications, and post-secondary education (Didier, 2018a; J. Kim & Park, 2020; Trampusch, 2010).

Nonetheless, reskilling the workforce as a policy requires combining the definition of the new skills/abilities and advancing to certification/credentialing systems with higher levels of transparency (World Economic Forum, 2021). That kind of demand forces the discussion regarding the traditional discussion of labor economics on the effectiveness of job training initiatives to a more institutional-center discussion on how the provision mechanisms could increase or hinder the effectiveness of that policy tool

(Didier, 2022). In the case of a scenario in which educational credentials are experiencing a process of redefinition by their availability, the multiplicity of sources and fluctuations on the institutional basis for credibility or market trust (D. Gibson et al., 2015; West & Lockley, 2016), the analysis shall not overlook the institutional dimension of training and certifications.

The third element to include in the problematization for policy design and implementation in the matter of technological change covers the domain of what implies the transition of economies from their current states to the envisioned scenarios taking up the socioeconomic benefits of the 4IR. The promises of the 4IR framers assume that a great deal of the gained efficiency and productivity would respond to countries that still hold a relevant share of manufacturing and industrial production activities in general. Whether the analysis of the world economic forum has mainly been based on larger economies, the availability of digital technologies could allow service industries to improve their margins by replacing service roles and optimizing the relationship with customers or suppliers. In this regard, while the image of economic efficiency is clear for companies and business-owners, it is still unclear to which extent economic gain would improve social well-being without solving the issues presented for the "*future of work*" and the "*future of jobs*" discussions.

The rationale presented from the business cycle approach to job polarization gives an edge in this discussion. The idea of jobless recoveries points out that even when the economy recovers from a crisis or a stagnation in their growth, there is a reallocation of capital and labor that does not lead to the same use of the workforce (Waddle, 2019; Zens et al., 2020). During the economic restructuring, companies and business owners do not necessarily keep the production structure or industry for their capital (Jaimovich et al., 2021). In this context, the opportunity window associated with the current wave of technological change (Perez, 2015) -for the labor market- not

only depends on how capital is reallocated in the economy, given the competition between analog and digital companies but in how government makes use of their policy tools to develop some areas of the economy (Mazzucato, 2011; Sachs et al., 2019) and which kind of labor demands those sectors can create.

Section 4. Discussion and Research Agenda Requirements for Policy Development

Until this point, I have explored the antecedents, formulated the characteristics of the current scenario for policymaking, differentiated the elements related to forecasted consequences of the advance of the 4IR, and problematized the perspectives related to the policy tools available to cope with the employment problem described in the literature. From here, three elements should be included as axes of policy development analysis during the current technological change process.

The first element is the required emphasis on a situated analysis of how the process of the 3IR crafted the current labor market situation. Since even in developed countries, the continuum between Skill Biased Technological Change, Routine biased Technological Change, and job market polarization have shown diverse manifestations, and any analysis should include the idiosyncratic characteristics of national economies. This point considers elements such as the industrial organization (previous configuration to the deindustrialization process), the historical feasibility of the offshoring process, the characteristics of the policy environment (i.e., educational and workforce, active labor market, and trade policies), trends for technological adoption (access and diffusion of new technologies), and internal-external market competitiveness, among others.

The second element includes institutional differences across countries that could alter the time link between the major events/process described in the literature,

altering the causal connections observed in the antecedents of the transitional model for workforce adaptation. In this regard, although not every process of technological change would lead to a polarized occupational structure of the labor market, the inferences regarding the changing value of skills usually associated with technological change would also answer to other causes, such as the late expansion of educational systems in developing economies. The analysis of how the labor market reacted to the shift in the demand for skills and education also must include the problem of human capital availability.

The third element moves from the historical process to the forecasted policy response using human-capital-based interventions. In the current setting, where digital technologies have expanded the supply of training opportunities, formal educational institutions could play a less relevant role than in the past. Since reskilling and upskilling agendas are based on scaffolding technological adoption through increasing the contingent human capital endowments of the workforce, the institutional mechanisms used to coordinate labor and the educational market should also be analyzed to establish the suitability of the provisioning mechanism for the projected skill demand.

CHAPTER 5

HAS THE CHILEAN LABOR MARKET A POLARIZED STRUCTURE? A HISTORICAL ANALYSIS

Section 1. Introduction

What does job polarization mean in the context of developing economies? The narratives on technological change have been established from developed countries' logic and economic processes, connecting a series of factors such as deindustrialization and offshoring, economic cycles, and educational reforms to the current structure of their labor markets. The mainstream narrative explains that since 1970 and more pronounced from the 1990s, industrialized countries have experienced a process by which middle-complexity employment has decreased its presence in the labor market compared to high- and low-complexity jobs.

The patterns of job polarization are central to explaining the increase in inequality in the last forty decades (Alvaredo et al., 2019; Piketty & Zucman, 2014). As Katz and Autor (1999) argue, income and wage distribution inequality are closely related to the disappearance of middle-skilled employment. Historically, that semiskilled workforce has been defined as middle-class workers or part of the middle-class household. That employment was often associated with manufacturing industries that demanded a well-trained workforce without college attendance. When globalization started, manufacturing companies in industrialized countries shifted their production to less developed countries, seeking to decrease production prices by focusing on wages (Manning, 2004). The consequence of that industrial policy, implicit or explicit, was

the destruction of jobs in the manufacturing industry, pushing the reallocation of workers into the service economy but with lower job quality and wages.

However, another explanation comes from the same narrative: technological change. During deindustrialization and migration to the service economy, the labor market was shaken by workplace computerization. Workplace computerization has been argued as one reason for wage polarization in industrialized countries. That phenomenon has been called skill-biased technological change (SBTC), where technological change was not neutral regarding wages or employment in national economies. Because of that change, the labor market increased the wage premium for high-skilled jobs and compressed the distribution for low-skilled jobs (Autor et al., 2003). The causal mechanism implied in SBTC was developed by Goos and Manning, and Salomons (Goos et al., 2014) as what we know as the routinized-biased technological change (RBTC), where computers were considered a substitute for labor, decreasing the demand for routinized jobs -replaced by technology- and increased the demand for cognitive-skills demanding jobs. Still, both hypotheses have been grounded in different analysis levels, where SBTC explains the process of wage polarization and RBTC explains the job market polarization. Both levels of analysis are often equalized in the literature but have different economic and policy modeling consequences.

SBTC interacts with employment problems at a macro level, explaining the shift in employment quality across the labor market. That focus is complementary to jobless recoveries (Jaimovich & Siu, 2012), where the recovery after an economic crisis (negative growth) leads to a reallocation of production factors. Following an economic crisis, economic recovery comes unattached to employment growth, changing the distribution of jobs across industries and occupations without returning the job loss caused by the crisis (Burger & Schwartz, 2018; Chen & Cui, 2017). For example, the

manufacturing industry did not recover from the job loss during the subprime crisis (2008) or the Asian financial crisis (1997), forcing workers' displacement to other economic activities.

At a meso-level, RBTC would interact with skill demand and other institutions in the labor market. That interaction would be the key to understanding why in some countries, workers performed better than in some countries compared to others. Oesch and Piccino (2019) represent an example of that inquiry line of inquiry. They argue that countries in the European Union have not experienced the adverse effects of job polarization in income distribution because of a long process of skill-upgrading (higher education expansion). Since the workforce has been experiencing increased human capital accumulation through specific educational policies and active labor market policies, polarization seems less significant than in other seriously affected countries (USA, U.K., Australia).

All those sources of change in national economies have altered the balance between labor and capital and, consequently, the organization of the labor market (Buyst et al., 2018). Still, the connection between SBTC, RBTC, and job polarization follows a rationale equated to technological determinism (Nolan & Slater, 2010), globalizing the reach and manifestation of technological change dynamics without a thorough analysis of countries' institutional setting and national idiosyncrasies that can explain why, when, and where the polarization of job market took place (Murphy & Oesch, 2018). An emergent portion of the research indicates that developing economies have not undergone a polarization process (Martins-Neto et al., 2021). The difficulty of finding evidence regarding the process could be explained for diverse reasons, ranging from the theoretical-causal approach to job polarization to the definition of the phenomena.

That is the case of Chile, where Gasparini et al. (2021), using data from PIACC and CASEN household survey (2003-2011-2017), showed no pattern of job polarization in routinized occupations approaching the employment polarization. However, Didier (Didier, 2021a) used the complete set of CASEN surveys between 1994 and 2015 to show that the Chilean labor market in the occupational structure presents a degree of polarization nearer to European countries' experience. Several factors could explain those differences also found in the literature regarding the process of job market polarization in developed countries: the timing of technological process (Adermon & Gustavsson, 2015), national economy industrial organization (Murphy & Oesch, 2018), labor and educational market coordination (specific policy environment) (Acemoglu & Autor, 2012; Katz & Goldin, 2007), and sociodemographic change (i.e., workforce aging, migration) (Lancia & Prarolo, 2012; Oesch & Piccitto, 2019). On the other hand, alternative explanations come from the specificity of the economic configuration in developing economies, including ex-ante wage distribution, technological adoption patterns (preferences and availability), and industrial organization (Martins-Neto et al., 2021).

In this chapter, I use the problematization of the transitional model of workforce adaptation (TMWA) and its first layer to analyze the technological change and labor market evolution in the case of Chile. This approach allows the analysis to consider the outcome of the process associated with the third industrial revolution (3IR) explained by SBTC and RBTC and create a coherent analysis of the determinants or antecedents of those changes. In this sense, the analysis seeks to define the sociohistorical process that accompanied the patterns of technology adoption to provide insights into how institutional features and national idiosyncrasies could have altered the pathway to job polarization. The rest of the chapter is organized as follows: Section 2 presents a brief problematization of the nature of polarization and its

measures, and Section 3 explains the methodological approach and data treatment for case building. The case will be presented in terms of the structure of the transitional model for workforce adaptation: Section 4 presents the evolution of Chile as an open economy; Section 5 provides information regarding the evolution of the technological ecosystem; Section 6 provides a background explanation for Chilean educational system expansion. Section 7 analyzes the educational and occupational composition of the labor market; Section 8 describes the process of wage polarization; and Section 9 explores the change in education's value through the analysis of credentials and schooling returns during the period assessed. Finally, Section 9 presents the concluding remarks considering the economic and policy dimensions of the polarization issue.

Section 2. Methodological Approach

This chapter follows a strategy for a case study aiming to analyze the fitness of the Chilean case to the broad narratives developed from the processes of technological change in developed countries. Since the model of workforce adaptation was developed from the mainstream approaches and evidence available for scholarly discussion, this method appears to be adequate to represent the possibilities of policy learning. In this regard, the section of the theoretical model that I will present for the analysis is the antecedents' layer, which covers all the sociohistorical elements that have served as background for establishing the causal links between technological change and labor market evolution.

As a qualitative method approach, case studies are not based on causal inference (Little, 1991). Thus, the evidence presented in this chapter should be considered correlational for statistical analysis. However, the value and contribution of this methodological approach are to provide detailed descriptions of the background for

variables of interest (Jaccard & Jacoby, 2010), allowing to build and assess comprehensive models of social sciences phenomena.

Before presenting the case, I will refer to data sources, information analysis strategy, and variables definition.

2.1 Data Sources

The chapter considers different sources of information to provide a depiction of the process of technological change in Chile, which are described as follows:

- (a) UN COMTRADE data (United Nations, 2022a): this data set corresponds to a compilation of trading data worldwide based on every country's administrative data. I compiled the historical data from 1976 to 2020 for this study.
- (b) Supplementary income survey (NESI): This survey is a module of the National Employment Survey, implemented yearly between October and December by the National Institute of Statistics (2021). The survey sampling design is nationally representative of the 15 years and older population who live in occupied houses across the territory. As an information collection survey, it has been updated through time considering changes in classifications (i.e., ISIC, ISCO). For the econometric modeling, I built a time series between 1990 and 2018, homologating the measurements across time.
- (c) Socio-economic characterization survey (CASEN): This survey is a critical information tool of the Chilean government to assess population wellbeing in several areas of public policy, including housing, education, health, occupation, and income. According to its methodological design, it

represents the Chilean population at the national, regional, and municipal levels, providing a detailed description of the population's living conditions. Since it has a more complex design, the Employment Survey contains additional information regarding schooling and training does not present in NESI data.

2.2 Treatment of Estimates

The survey-based statistics (CASEN and NESI) were estimated using the survey methodology for extrapolating the sample results to the population, including the specificities of the multi-stage sampling process (strata and unit of analysis), and the use of expansion factors associated with the design. For the case of statistical analysis, I consistently use the inverse probability of selection as a weighting strategy for the cases.

Regarding the data from COMTRADE, as an administrative data set, it is assumed to represent the complete range of commercial exchange between countries. Before estimating any statistics, I check inconsistencies across reporters, showing no data-related problems that could affect the estimated magnitudes.

2.3 Variables of Interest

The analysis provided in this chapter is based on different variables that were built from data present in the surveys, that I will define the procedures as follows:

(a) Hourly wages: Following the practices in economic research using the human capital framework, I use the natural logarithm of the hourly wage. For building this variable, I use the questions regarding the monthly income provided by their principal occupation and the hours worked for that occupation. Then I divided the

income by the hours, obtaining the value of the hourly wage. That value was adjusted by inflation using as a reference the last year of the survey time series built. Finally, I estimated the natural logarithm of that adjusted value.

- (b) Educational Credentials: I used the guide for composite variables for CASEN and NESI surveys to define the situation of study completion status. The procedure used the highest level of education intended and then compared it with the self-report of study completion and the years involved in those educational levels. When the three questions were consistent, the credential status was created as a binary variable representing elementary education, secondary education, secondary vocational education, and tertiary education (Higher Vocational Education and Training [HVET], associate degrees, and university degrees).
- (c) Economic Complexity: The estimates are based on the administrative data from COMTRADE and follow the “fitness” approach from Mariani et al. (2015).

2.4 Assessment of Relationships

The analysis of the relationship between educational and labor variables considered the application of a correlational analysis on yearly samples. Those estimates consider the implementation of an OLS approach, using equation (1) specification:

$$(1) \ln(\omega) = \beta_1 cred + \beta_2 HC + \beta_3 ES + \beta_4 Geo + \varepsilon$$

In equation (1), the dependent variable is the natural logarithm of hourly wage. The β_1 represents the sheepskin effect (the differential value of holding a credential). For its construction, the variable cred is a binary variable that takes the value of 1 if the individual has obtained their higher educational level intended and 0 otherwise. β_2 summarizes the relationship between human capital characteristics (schooling years, tenure, tenure squared, gender, marriage, age group, and educational

mismatch) and labor income. β_3 includes occupational structure, economic activity, and educational level. Finally, β_4 represent geographical variables (region and urban/rural location).

The case presentation will use these estimates to build and represent some trends for credentials and schooling relationships with labor market outcomes.

Section 3. Job Polarization Measurement

From an economic perspective, polarization has presented different meanings. For example, in econometrics and theoretical development, creating polar conditions for modeling allows researchers to test the robustness of their assumptions and conclusions. In the case of job market polarization, the explicit definition of the concept comes from an observation regarding wage distribution. Autor et al. (2003) made the transition between income distribution to wage distribution, centering the analysis on how the jobs that were historically in the middle of the distribution shrank during the eighties and nineties, decreasing the number of people in the middle -or around the statistical average- of the wage distribution. That kind of analysis was followed by a characterization in which the salaries on the lower tail of wage distribution (low-skill or low-level) became stagnant, compressed, or decreased in value compared to the higher tail of the distribution. However, that depiction failed to see in the same data sources that the wages of the middle-level jobs did not decline compared to average wages in the low-skill occupations and, as a broad notion, cannot account for the evolution of the occupational demand (Boehm, 2013).

The same assumption is shared by Goos and Manning (2007), referring to the polarization of the job market as a job quality problem. In their understanding, the quality of the job is defined by the associated wage premium. The economics of

education often exploits this connection to link the results in the labor market of certain educational attainment, as is the case of signal theory (Spence, 1973) or human capital theory (Mincer, 1958), which entangle educational attainment, workers' skills, and productivity with wages as an outcome. Consequently, the paradigm in which the concept emerged was the neoclassic economic approach, assuming certain conditions on agents' coordination in the labor market.

However, the evolution of SBTC and RBTC directly linked wages and job requirements. The literature links the occupational dimension of the labor market with the wage distribution using measures of routinization or routine intensity of jobs (Yuhong & Xiahai, 2020). In this research area, economists have proposed an equivalency between jobs and occupations for empirical analysis, which neglects mostly the sociology of occupations and occupational psychology traditions. At this point, the definition of a middle-skilled job would be represented as an extension of the wage distribution and linked to a positive valuation as lovely jobs (compared to lousy) (Goos & Manning, 2007). In the long run, the job market polarization started to include measures regarding employment (e.g., underemployment, part-time versus full-time, number of hours) (Kalleberg, 2011), generating a blurry of the nature of job polarization and its effects on the workforce.

The link between occupational structure and wage distribution provides an interesting angle to analyze polarization phenomena. The International Labor Office (ILO) has developed consistent efforts to create a standardized and comparable frame to summarize the nature of occupations worldwide, named the International Standard Classification of Occupations (ISCO). ISCO brings a clear structure to analyze the labor market, which is comparable across countries regardless of the internal classifications developed by each country. That is the base of Sparreboom and Tarvid's (2016) reasoning, which problematizes job market polarization measurement using ISCO

classification and not income/wage measures, to define in a standard way what would be considered middle-level employment. In their reasoning, only elementary occupations can be considered low-level or low-skilled jobs, while medium-level employment corresponds to major groups 4 to 8, and the high-level job market will consider major groups 1 to 3: managers, professionals, and technicians. This grouping strategy presents an alternative understanding of job polarization, providing more flexibility for comparisons regarding a specific occupational structure in a labor market and its national particularities.

The Job Polarization Index (Sparreboom & Tarvid, 2016) appears as a relevant alternative for countries without a system that connects skills-abilities to job descriptions, as O*NET data does in the United States. In the same vein, compared to other measures of polarization as the ones of Wolfson (1994), Wang and Tsui (2000), and Esteban and Ray (1994), the JPI does not assume an ideal distribution of the occupational structure, and it is not based on the wage distribution. That provides three advantages for applied research on the topic: first, since the job market polarization is detached in its measure of the wage distribution, JPI allows to connect patterns of the employment-occupation structure of the labor market with its effects on wage distribution. Second, it allows decomposition to differentiate the phenomena of skill upgrading (an increase in the stock of human capital) and proper polarization or skill downgrading (an increase on the lower tail of the distribution of jobs against the share of middle-level jobs). Third, provide a dynamic measure of the polarization process, allowing for analyzing the phenomena as a process and not only as a result. The consequence of this property is that it helps summarize the effects on the job market structure of economic and environmental shocks, keeping the reference on the prior evolution of the job market.

The JPI is defined as follows:

$$(2) JPI = \frac{1}{2} \times (\underline{\Delta} l + \underline{\Delta} h) \times (1 + |\underline{\Delta} h - \underline{\Delta} l|) \times 100,$$

where the operator $\underline{\Delta}$ Represents the average variation in the time series of the share of a specific type of occupation (low level [l] or high level[h]), and the first term in the parenthesis represents the evolution of the composition of medium-level jobs. The second term represents the imbalance between occupational categories; this index ranges between -100 and 100. Values below 0 represent a direction in which middle-level employment is recovered, while values above 0 represent a polarization movement. The second term should be interpreted with detention to differentiate between skill upgrading and true polarization.

Sparreboom and Tarvid (2016) suggest that the JPI should be analyzed in terms of a time series operator, which should include long-span trends (e.g., five years) to ensure the stability of the index. The problem comes from the dynamics of reallocation and job creation in the periods evaluated, especially when the problem of technological change is considered, where averaging the trend does not allow a depiction of the adjustments of the labor market to external conditions. However, the JPI has two elements that could be presented as shortcomings: first, the sensibility to short and long trends, and second, the definition of a middle-level job from an occupational perspective. Regarding a middle-level job, the measure homogenizes some occupations that could present a significant variability in the occupational market. That last element should be considered carefully in the analysis of less developed countries, where human capital accumulation presents a distinctive distribution across occupations not shared with industrialized countries.

Section 4. Chile as an Open Economy

The first step in analyzing the causes of the polarization problem is to address the concurrent factors summarized in the RMWA in the antecedent's layer. Here, de-industrialization and offshoring play a significant role in decreasing the relevance of the manufacturing industry, destroying a significant share of middle-level jobs. That, combined with the history of the financial crisis in developed economies, has proven to be a powerful mechanism to explain the polarization of the labor market. Nevertheless, to adapt those narratives to another context - the Chilean one- it is relevant to consider the specificities of the recent economic history.

During the second half of the twentieth century, the Chilean economy underwent a series of significant transformations following the tensions and trends of world politics. Chile attempted to solve its economic development problem by applying the Import Substitution Industrialization (ISI) model between 1950 and 1973. The ISI history in Chile was characterized by an increase in economic growth without a substantive increase in acquisition power of the population, a concentration of exports share in a reduced number of economic groups which led to a distortion of prices in the production process and export of commodities, and a significant vulnerability to external shocks (Sapelli, 2003). This vulnerability has been based on the over-dependence of the national economy in exporting commodities with low added value, as was the case of saltpeter until 1919 and, currently, the copper mining industry. Since a large portion of the economy operated based on commodities production and exports, every shock in the international market (like the oil crisis during the seventies) significantly affected overall economic system performance.

Those results led to a polarized understanding of the economy to reduce social problems and decoupled from the primary orientation as an industrial policy

(Hirschman, 1968; Silva, 2007). The response to polarization was the authoritarian regression of the political system during the seventies and eighties. This authoritarian regression was led by a far-right dictatorship between 1973 and 1990. During the dictatorial regime, the Chilean economy was set as a neoliberal economy, decreasing the size of governmental structures, reducing the catalog of civil and labor rights, following the trends of the "Hollow State" of Reagan in the U.S. and Thatcher in the U.K. (see O'Neill (1996) for a longer description of the Hollowed state). Those changes in the structure of the economy led to a financial crisis in 1982 and a series of sanctions in the period 1973-1991, which were primarily unilateral by Belgium, Denmark, Germany, Mexico, Soviet Union, Sweden, Finland, Norway, Netherlands, United Kingdom, and United States (Felbermayr et al., 2020). Most of those sanctions were partial prohibitions on exporting some products, aiming to press for restoring democracy. Since the return of democracy, Chile has not received another economic sanction, not unilateral or multilateral (Kirilakha et al., 2021), and has maintained a democratic development process as a part of the third wave of democratization (Huntington, 1996).

Since the 1982 economic crisis was under a dictatorship regime, the official stats available for that period are biased under the pressure of the government to keep control over economic performance. Still, the evidence in the related literature shows that the GDP decreased by 14.3%, the unemployment rate grew to 23.7%, and the national currency was devaluated by 18% (Meller, 1996; Ruiz-Tagle & Urmeneta, 1984; Schkolnik & Teitelboim, 1988). The discussion suggests that the crisis and the later economic stabilization period led to the first stage of the country's deindustrialization with the bankruptcy of manufacturing companies. Still, since the 1982 crisis, Chile has not experienced a new economic crisis as defined in the jobless recoveries, two-quarters of economic contraction (Banco Central de Chile, 2022a).

Consequently, without relaxing to a great extent the approach of jobless recoveries to the job market polarization, it is not possible to argue that Chile experienced a similar process as the evidence indicates for the United States, taking aside the possibility of explaining the change in the occupational structure regarding using that frame.

During the last thirty years, the Chilean economy has been designed as open and free as the institutional regime allows, being Latin America's most open and free economy (Legatum Institute, 2019; Miller et al., 2021). Both definitions, free and open, have fueled the economic expansion (i.e., GDP and the volume of imports and exports), as is shown in figure 3. From 1988 to 2019, the Chilean economy increased seven times the money in imports and exports, given free trade agreements with the European Union, United States, China, and marginally with the MERCOSUR.

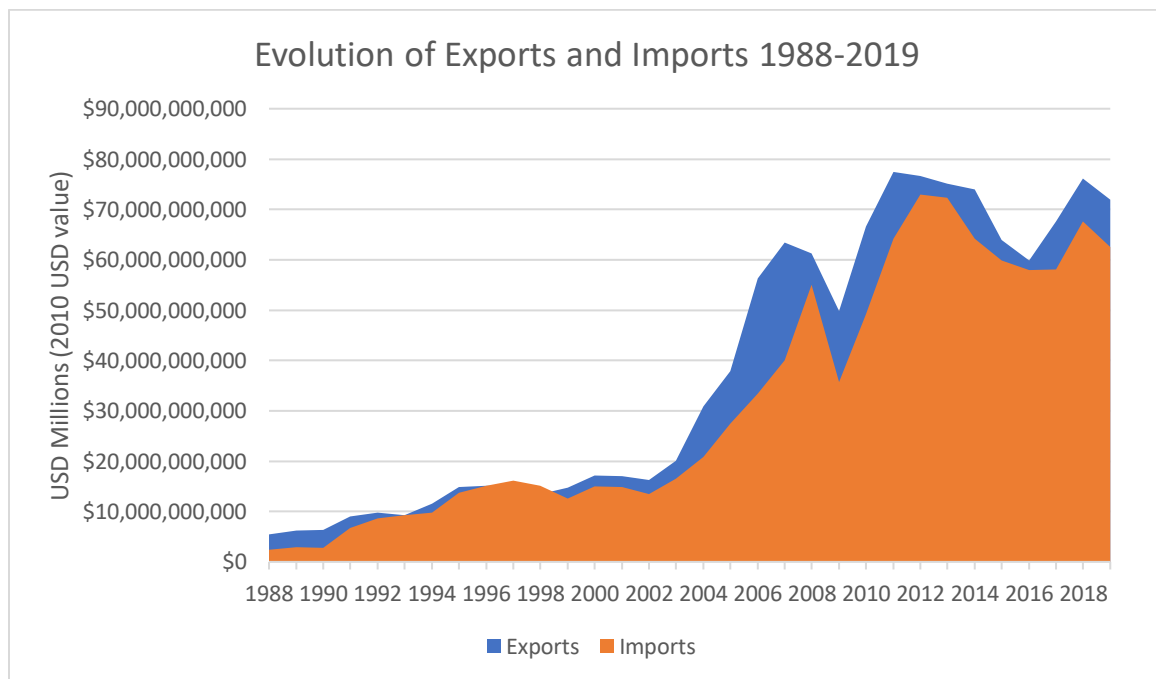


Figure 3. Evolution of Imports and Exports 1988-2018. Data source: UN COMTRADE. Adjusted prices for USD 2010 value.

Another way to represent economic evolution is through the economic complexity index (ECI). ECI works as a measure of economic diversification in exports and allows the observer to visualize the production capability of an economy. More complex economies are more diversified in their production, allowing them to not depend on a handful of resources to sustain their economic activity (Hidalgo & Hausmann, 2009). Following the recommendations of Mariani et al. (2015), figures 4 and 5 use the “fitness ECI” to graph the evolution of Chilean, considering the centrality of the exported products on the international trade network.

Figures 4 and 5 show Chilean economic complexity's long-term evolution from 1976 to 2020. Data before 1976 were excluded not to cover the period of social and governmental breakthrough, including the socialist government of Salvador Allende and the immediate consequences of the dictatorship regime. The evolution in the period shows that the Chilean economy has systematically decreased the variety of products in the exports, decreasing the amount of knowledge involved in the production process. Consequently, the worldwide ranking of the Chilean economy decreased from 41st to 77th. Compared to a time series, the Chilean economic matrix increased in complexity from 1976 to 1997 and stabilized in the following years. That could be explained by the implementation of free trade agreements, the preferred export products, and its consequences on the degree of specialization of industries. The added value of Chilean products has stagnated, even decreasing the number of elaboration procedures involved in producing those products (e.g., mineral exportations have tended to be more raw materials and lower levels of complexity in related goods, as shown in UN COMTRADE data).

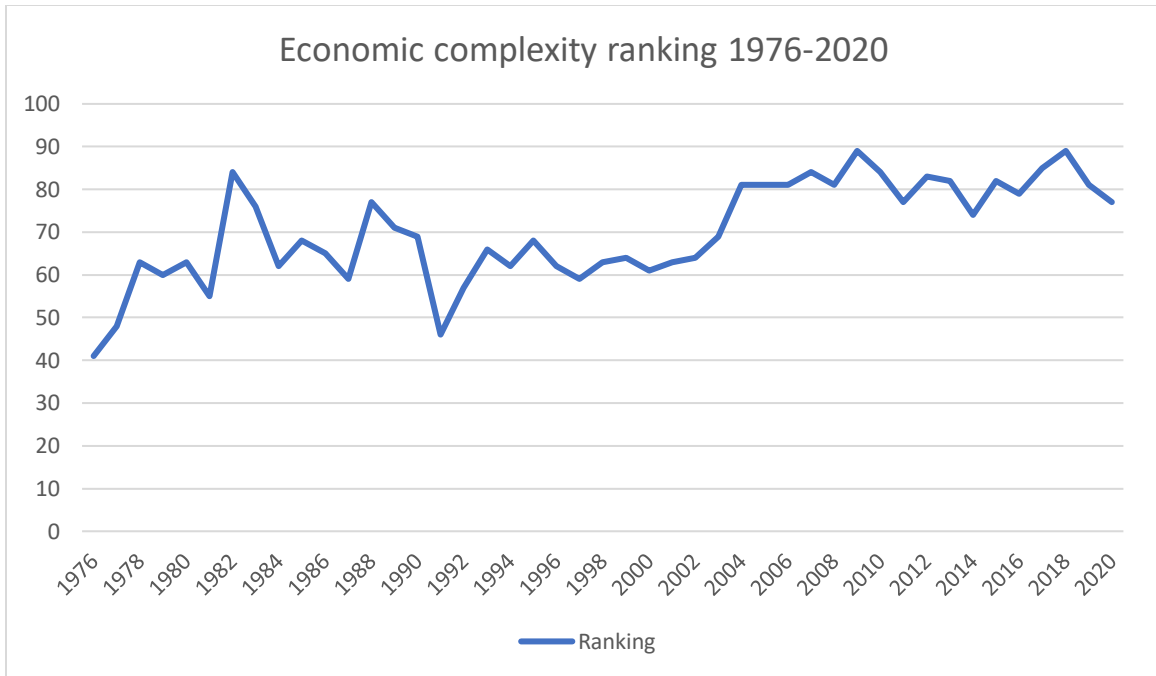


Figure 4. Economic Complexity Ranking 1976-2022. Imputed series. Source: UN COMTRADE data.

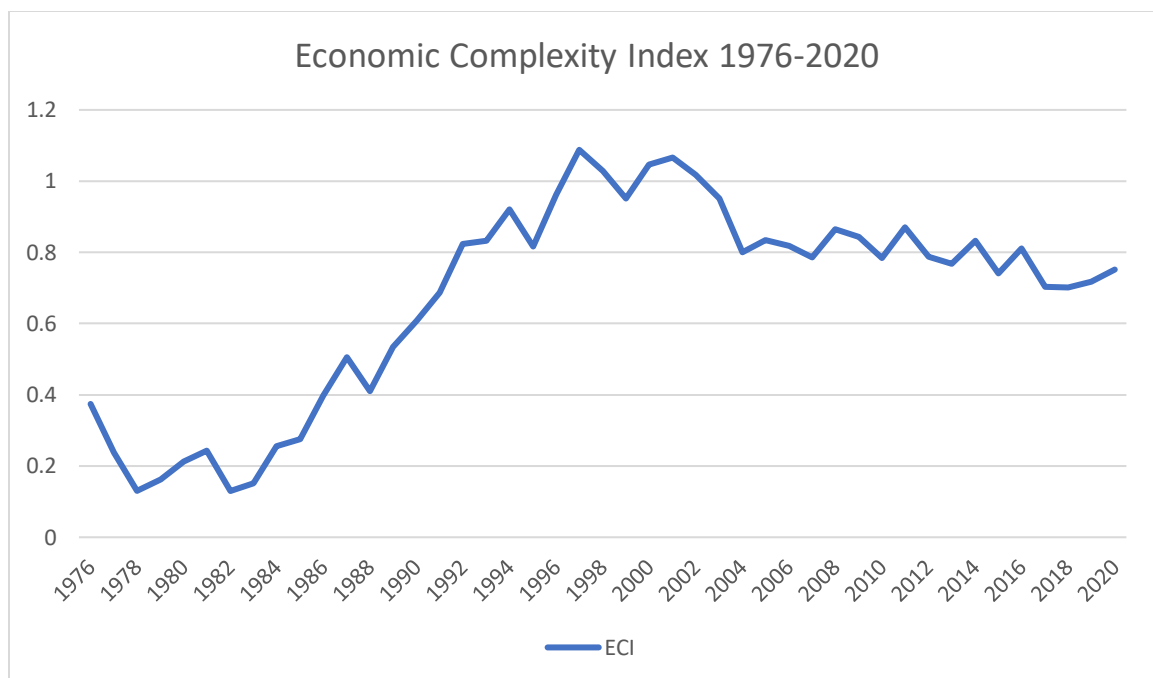


Figure 5. Evolution of Economic Complexity Index 1976-2020. Imputed series. Source: UN COMTRADE data.

From 1990 to 2018, the country experienced a significant change in the employment structure, summarized in figure 6. Using the categorization of The International Standard Industrial Classification of All Economic Activities (ISIC), I built a time series to show the evolution of the three significant clusters for industry classification: Agriculture, Industry ("Mining and Quarrying," "Manufacturing," "Electricity, Gas and Water," and "Construction"), and services ("Wholesale and Retail Trade and Restaurants and Hotels," "Transport, Storage and Communication," "Financing, Insurance, Real Estate, and Business Services," and "Community, Social, and Personal Services"). Regarding net change, agriculture reduced its employment share from 19.1% in 1990 to 9% in 2018, decreasing its participation by 10.1% in the evaluated period. In the industry case, it decreased less dramatically from 25.1% in 1990 to 21.6% in 2018, a contraction of 3.5%. Finally, the service sector increased its relevance by 13.6% between 1990 and 2018.

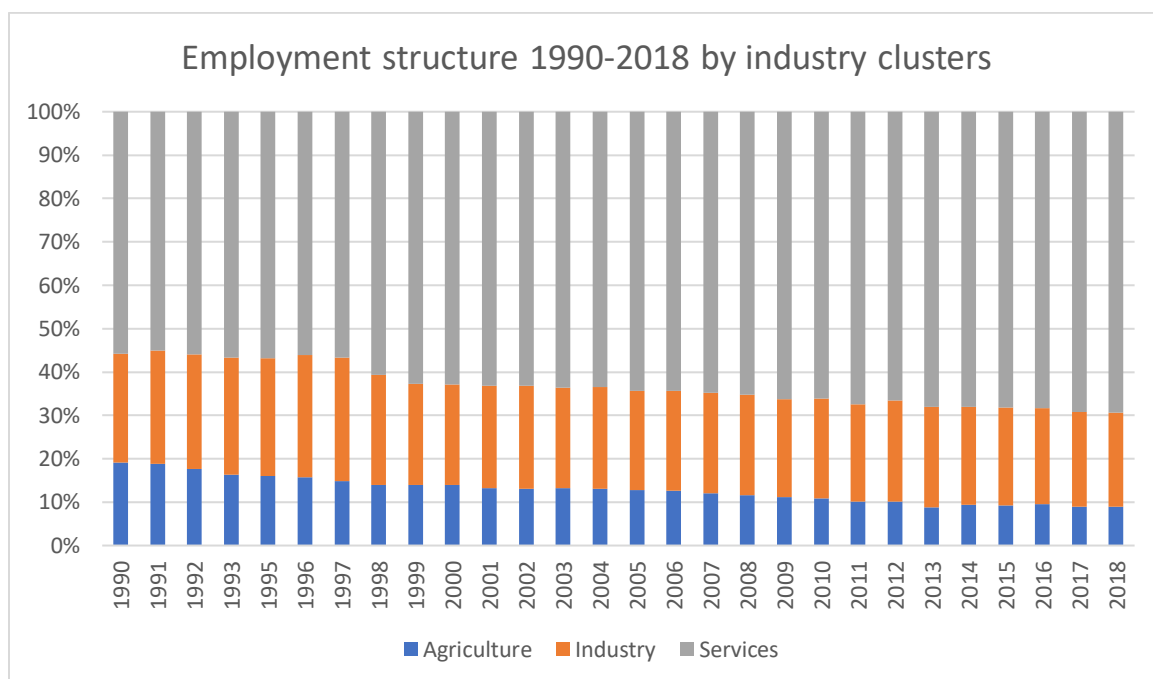


Figure 6. Employment Structure 1990-2018. Source: NESI.

Since the clustered presentation of industry classification shows average changes in employment structure, figure 7 shows the evolution of three representative industries: Community, Social, and Personal Services; Manufacturing; and Agriculture. Alike figure 4, agriculture employment decreased by 10.1% between 1990 and 2018, manufacturing employment decreased by 6.1% in the same period, and community, social and personal services increased their participation by 2.7% in the reference period. Whether explained by technological change, by the means in the production process, or by the competency carried by free trade policies, the relative relevance of the manufacturing industry decreased over the average of its cluster (6.1% versus 3.5%). While the share of manufacturing employment represents the process of deindustrialization, agriculture-related employment represents the relevance of food production and older social structure (agrarian society in the first half of the twentieth

century), employment-related to the community, social and personal services also can capture the evolution of public employment (primarily represented in this category).

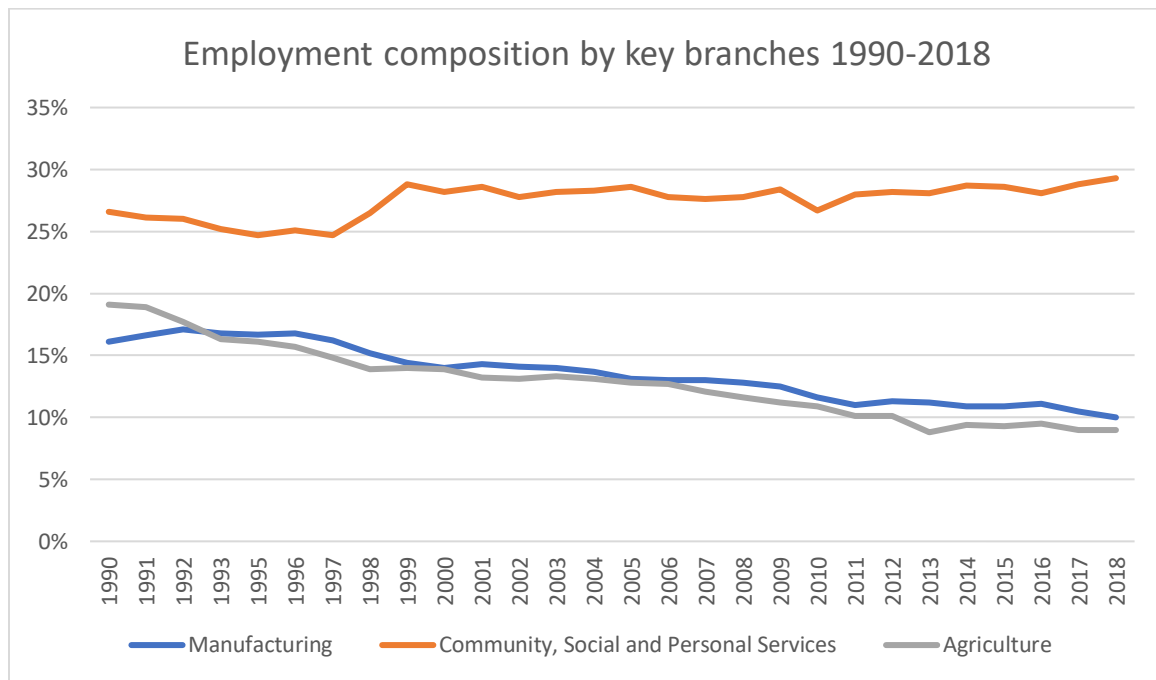


Figure 7. Evolution of Employment Composition for Manufacturing, Services, and Agriculture.

Source: NESI.

The trends in the employment patterns are consistent with the GDP by industry cluster estimated by the Central Bank for the period 1990-2019 in figure 8:

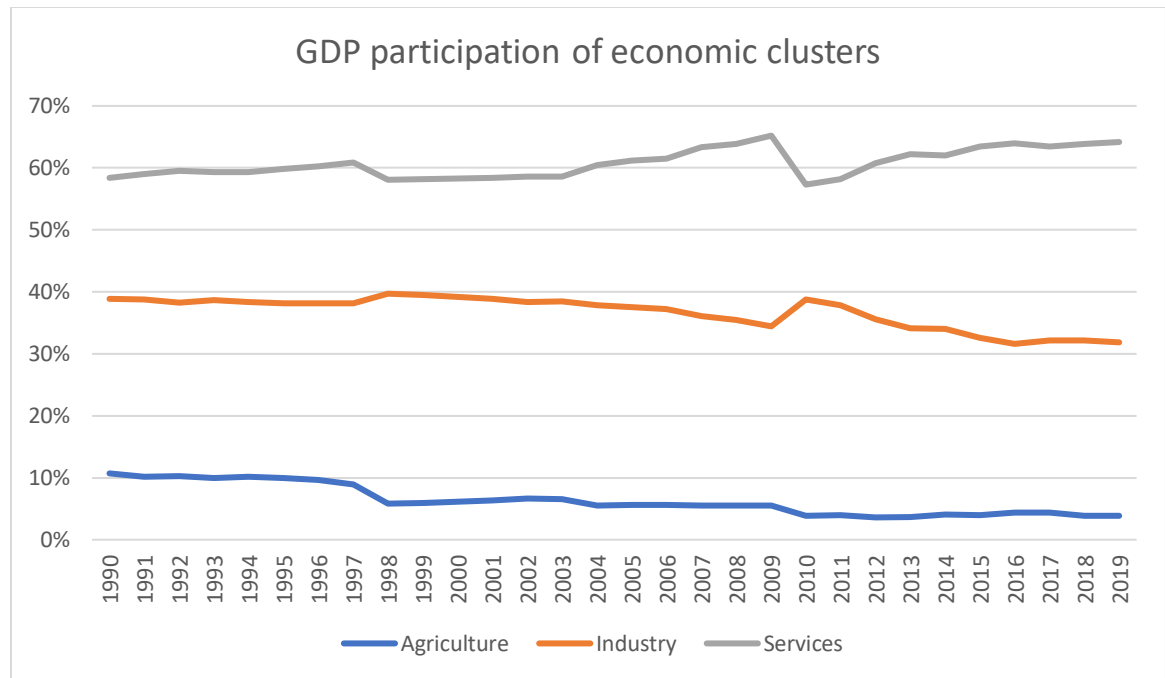


Figure 8. GDP per Industry Cluster 2010-2019. Source: Banco Central de Chile (2022b)

Finally, it is essential to remark that between 1990 and 2019, the trend of the Chilean economy's dependence on mining activities was displaced by financial services as the most relevant economic activity. Since the 2000s, the financial sector ecosystem has been the most complex in the Latin American Region.

Section 5. Technological Ecosystem

The TMWA considers two main drivers for job polarization: de-industrialization and technological change. In this regard, technologies associated with the 3IR include computerization and ICTs, which framed the evolution of the substitution between labor and technology in the production process. Still, as was problematized by Martins-Neto (2021), the availability of those technologies and the patterns of technological adoption are critical to understanding the presence or absence of job polarization.

As a net importer, the import flux determined computers' availability. Between 1983 and 1990, the average of imports was about USD 46 million, increasing from 1991-2003 to an average of USD 67 million yearly. From 2004, the average imports reached USD 552 million, showing a spike in 2012 with a net import of USD 992 million. Figure 9 shows the evolution of computer imports, showing the long trend of computers for business use to consume goods.

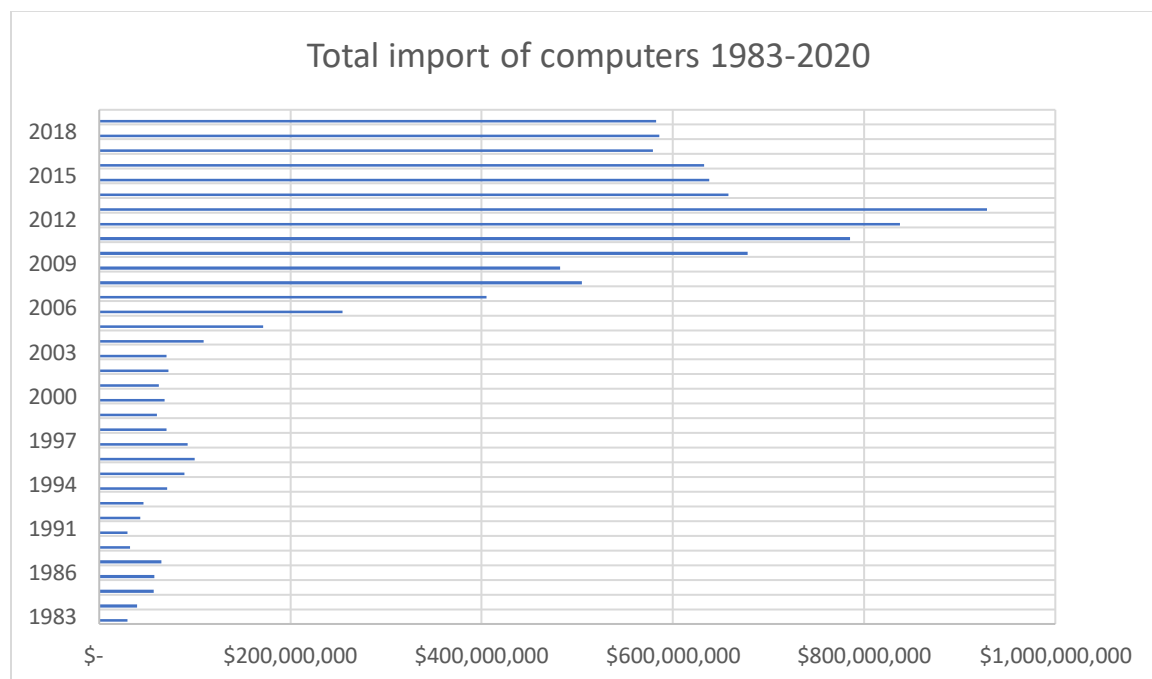


Figure 9. Net Import Value of Computer Imports 1983-2020 (adjusted 2010 USD). Source: UN COMTRADE data

In the case of cell phones, technology will be a determinant of the expansion of the digital economy; that evolution was followed between 1989 and 2004. Table 2 shows the evolution of the computers' stock between 1989 and 1997 and the rate of computers by 100 habitants. Regarding cellphones, the progression of technological adoption was determined by the limited penetration of telephone lines in rural areas

outside of the big cities, relatively accessible prices for cell phones, and relatively competitive prices across companies.

Year	Computers/100 habitants	The stock of computers (thousands)	Cellphones/100 habitants
1989	0.9	85	0
1990	1	130	0
1991	1.3	176	0.3
1992	1.7	229	0.5
1993	2.2	296	0.6
1994	2.6	369	0.8
1995	3.3	474	1.4
1996	3.9	559	2.2
1997	4.5	653	2.8
1998			6.5
1999			15
2000			22.5
2001			26.7
2002			36.7
2003			41.4
2004	13.5	2153	56.1

Table 2. Computerization 1989-2004. Source: UNDP (2006) and Comision Presidencial TIC (1999)

Figure 10 shows the evolution of the technological ecosystem by following household computer-ownership, computer access, mobile device ownership,

household internet connection availability, and internet access using the estimates of the socioeconomic characterization survey. In the case of computerization advance, between 2003 and 2017, the population with owned computers moved from 7 to 19%. Still, the availability of computers for use (i.e., public and company computers) doubled or tripled ownership between 2003 and 2009, reaching 43% of the population. Regarding cellphone availability, the average ownership moved from 33% in 2003 to 80% in 2017. Following the same trends as computerization and mobile communications, internet access advanced from 3% to 24% for household connections (different from cellphone connections), and internet access advanced from 27% in 2003 to 68% in 2017.

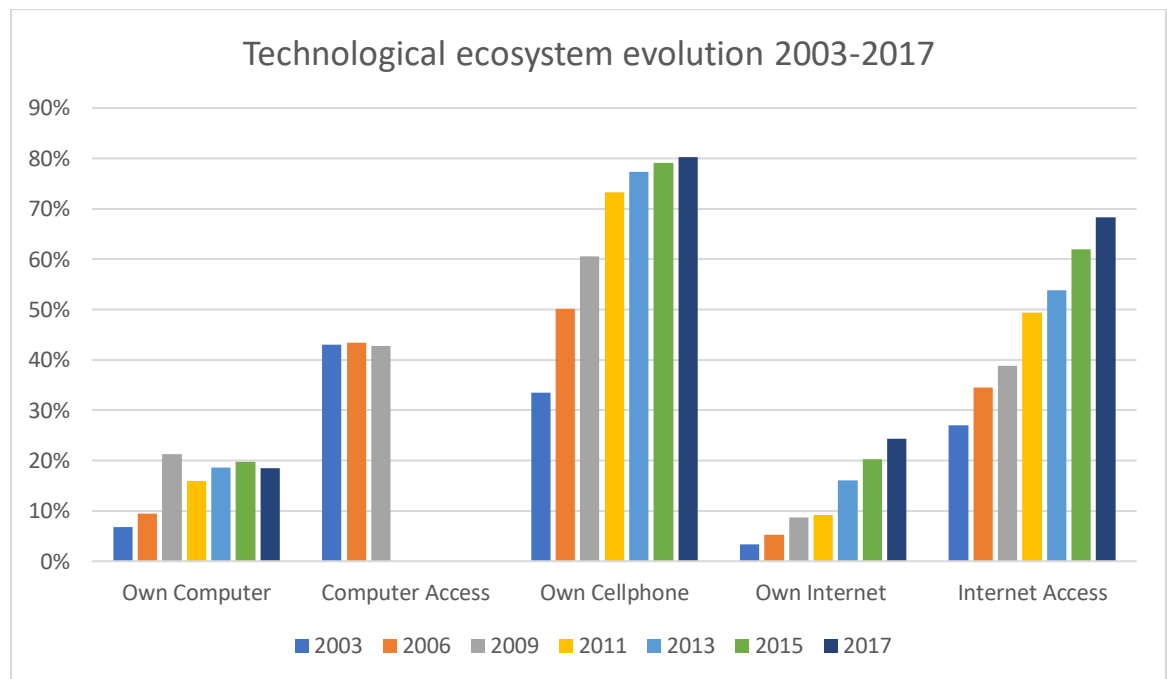


Figure 10. Computerization, Mobile Telecommunications, and Internet Access Estimates (2003-2017). Source: Socioeconomic Characterization Survey.

Interestingly, the data regarding the technological ecosystem indicates that computerization as a broad adoption pattern was substituted by access to mobile

technologies, including cellphone ownership and internet access. Theoretically, the patterns depicted from 1989 to 2017 show recent technological change from 3IR (computerization and ICTs) to 4IR (in its digital economy dimension). That overlap should be considered regarding how the workforce has adapted to the changing setting of economic activities and their respective production functions.

Section 6. Policy Environment: Educational Expansion

The second layer of the analysis of the antecedents for the workforce adaptation to technological change includes the policy environment that conditioned the coevolution of labor and educational markets. In this case, as the literature review suggests, the primary dimension obtained from developed countries' experience is the change in the human capital stocks to support the shift in the skill demand. Thus, I will provide a brief depiction of the evolution of the Chilean educational system.

Historically, the educational system has expanded in three different moments, with its political economy-related problems. The first moment occurred during the dictatorship regime (1973-1990), which modified the institutional regulations on the educational system, moving the public supply for elementary and secondary education from a central administration to local government administrative responsibility (municipalization). The most significant consequence of this change in the administration strategy was an increasing pattern of educational segregation. Since the funding and administration of schools were at the local government's level, educational policy decisions and implementations were subject to the wealth of communities, tax revenues, and, more relevantly, to the political capture of the State (i.e., spoils system). In the long run, the liberalization of elementary and secondary education supply increased the share of semi-public, through a voucher system, and private schools, decreasing public school funding and negatively affecting educational quality.

The liberalization of education during that period also involved tertiary education. First, the dictatorship regime decreased the funding for public universities, divided them arbitrarily, and forced those universities to be sustainable, relying on the enrollment rates and local demand for education. Second, the regime lowered the requirements for private and for-profit university creation. As a consequence, the competition for student enrollment increased over time. Still, those universities were non-selective, attracting students with lower academic performance during their secondary education. Since the oversight of the central authority was scarce (Ministry of Education), the private provision of education tended to be of low-quality, creating problems later on in university academic degrees valuation in the labor market (Didier, 2021b) and faulty administration leading to bankruptcy (i.e., *Universidad ARCIS*, *Universidad del Pacífico*, *Universidad de las Condes*, *Universidad del Mar*) or disappearance of institutional reference or those academic degrees.

The second moment of expansion began from the democracy recovery in 1990, covering the secondary and tertiary levels again. The expansion of secondary education occurred through two significant reforms undertaken in 1997 and 2003. The first implied the extension of the school-day length, almost doubling the prior standard. This expansion of the time considered in the school day initially aimed to provide a secure space for extra-curricular activities, granting a more comprehensive educational experience. However, the pressure to improve standardized test results across schools led to increased traditional subject hours (math and language) in opposition to physical education and arts. Consequently, some criticism arose from students and scholars regarding the quality of the education provided under this scheme (Bellei, 2015; Bellei & Cabalin, 2013).

The second moment for the secondary education expansion was in 2003 when the general law of education was modified to make compulsory the completion of

secondary education (Cox, 2006; Hinostroza et al., 2003). As a result, educational drop-out decreased, and alternative programs for ensuring secondary education completion were implemented (i.e., night schools, fast graduation schools, modification of curricular directives on educational level repetition). This change in educational policy led to an increase in the average schooling years for the working-age population.

The second wave of expansion for tertiary education was produced by changing the availability of funding alternatives. Before 2006, there were three major strategies for funding: a public loan system with socioeconomic inclusion criteria (*Credito Solidario*), own family funding, and scholarships (with meager participation). However, that structure was susceptible to income distribution, creating uneven access conditions for middle-income families (Didier, 2021c). Given the low repayment levels of the public loan system and addressing the subsidiary role of the Government established in the Chilean Constitution, the new instrument aimed to remove the burden of unpaid debt of unpaid loans by creating a funding tool. This new instrument to fund higher education studies was based on an intervention in the financial system to solve a market failure (incomplete market). The result was the creation of private loans through a policy named "*Crédito con aval del Estado*" (CAE) (World Bank, 2011). In this reform, the government acted as a guarantor of loans, decreasing the risk of debt-based access to higher education. The consequences for the educational market were massive, allowing excluded families to access higher education (universities and high-level vocational education) (Espinoza, 2008; Uribe, 2017).

Another related change from the expansion of higher education was the increased demand for advanced degrees and professional certificates (Didier, 2018a), showing a steady increase from 2006 until the date (CNED, 2019). This increase in the supply was accompanied by regulatory changes, shifting the nature of master's degrees from

purely academic degrees to more market-oriented degrees in 2013 (Comision Nacional de Acreditacion, 2021). Also, the government implemented policies to increase access to graduate studies through loans and scholarships (Salas et al., 2017). In the case of loans, the government used the same strategy, approach, and justification as the CAE tool (Riveros et al., 2016).

In the third moment, in addition to the increase of undergraduate degree suppliers on the for-profit side of the market, the government increased the number of public-funded universities and vocational education institutions in 2014. In 2016, the government expanded universities' funding by covering the tuition cost for 60% of the lowest-income families.

All those reforms have conditioned the availability of human capital stock through a longstanding process of skill-upgrading and creating the opportunity for upskilling by the flexibilization of access criteria for higher education institutions. In the next section, I will provide an integrated vision of how those policy changes interacted with the labor market structure.

Section 7. Educational-Occupational Structure of the Labor Market

The skill-upgrading process in the transitional workforce adaptation model appears as an enabler of the later process of job polarization. Since the process of occupational upgrading is conditioned by the availability of educational credentials and the labor market's job sorting strategies, changes in the policy environment as the expansion of the complete educational system, are critical to depict the evolution of the labor market.

Figure 11 shows the workforce's educational attainment evolution from 1990 to 2018 from the occupied population. While the literature on the educational system considers different arrangements for secondary or middle school, it is necessary to

clarify that complete or some vocational education covers students under a special curriculum regime during the 9-12 years of compulsory education and specific technical skills defined by the Ministry of Education. As opposed to the scientific-humanist education curriculum, these students exit secondary education with a middle-level technician degree (depending on the specializations offered by the school).

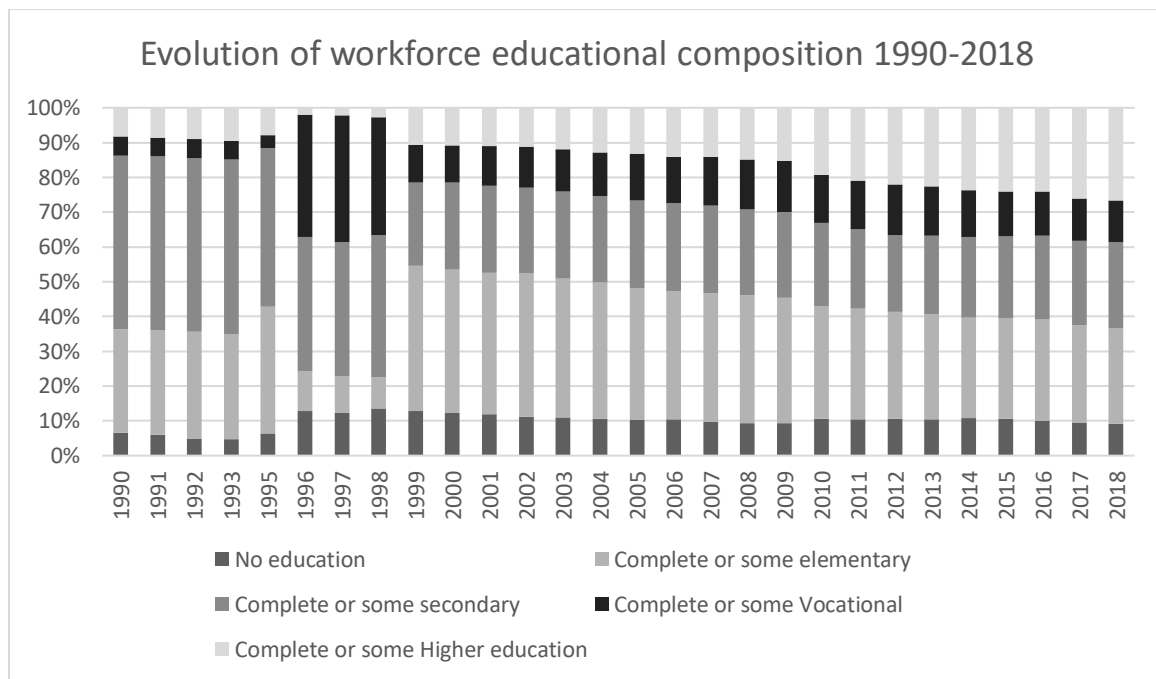


Figure 11. Educational Composition of Chilean Workforce 1990-2018 (Highest Educational Level Intended). Source: NESI.

Figure 11 shows the long-run evolution of the educational reforms applied in Chile. People with no educational attainment have decreased their labor market share consistently and steadily since 1998. Some policies to re-engage school leavers were implemented to grant the basic levels of education (elementary and secondary), providing arrangements in the curriculum to finish their incomplete educational cycles. Those who had only elementary school or some elementary school also decreased their share in favor of higher levels of educational attainment. In congruence with Didier's

(2021b) analysis, expanding higher education also increased enrollment in higher levels of vocational training, increasing the presence of people with higher education in the labor market. At the statistical level, the situation described is consistent with the notions of skill upgrading in the labor market discussed by Oesch and Menés (2011). However, more in-depth analysis is required to hold this perspective, especially regarding the nature of the educational degrees promoted by the higher education expansion (e.g., the balance between high-level technician degrees versus traditional academic degrees).

In an alternative examination of the evolution of educational composition, three elements should be considered. First, the change in the trend of the average schooling years in the population given the reforms in 2003 and 2006. Second, the change in the availability of credentials, and third, the change in the educational composition of occupations.

Figure 12 summarizes the change in the average schooling years, considering the real trend (observational data) and the forecasts provided by a linear trend analysis. Without the compulsory education reform in 2003, the average schooling years would have started from 8.40 by 1990 and finished at 8.43 by 2018. When the analysis was repeated with a time cut associated with CAE reform in 2006, the final point of the trend would have finished at 9.59. Both arriving points are lower than the real average represented in the real trend line (9.64).

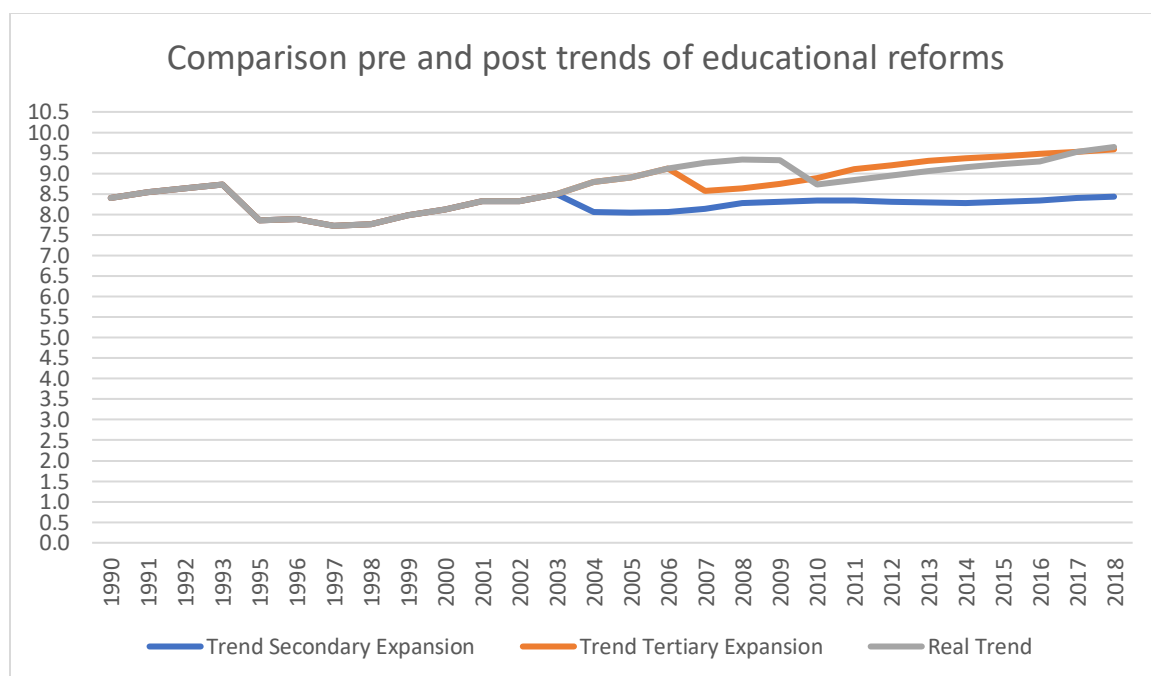


Figure 12. Comparison Between Pre and Post Trends of Average Schooling Years by Educational Reforms Timing. Source: NESI

Consistent with the preliminary data, figure 13 shows the availability of educational credentials in the occupied workforce. As can be observed, the trends show a consistent pattern of skill-upgrading in the workforce, increasing the volume of the occupied workforce which finished their studies. In this regard, it is possible to argue that elementary and secondary vocational education sustained a stable penetration pattern in the labor market. Still, the changes are clustered in secondary education and tertiary education credentials. The evolution of secondary education share appears to show a significative uptrend since 2013, led by the compulsory status of that educational credential, but also because of the volume of new students that entered and finished their studies in the post-reform period.

Similarly, higher education presents a break in its trend since 2010 and only have increased since then. The stability of elementary and secondary vocational education shares could be explained due to the lack of supply increase of those credentials and

the intrinsic connection between elementary and secondary education. Thus, it is possible to hypothesize that expansion effects were produced by the young population, while older workers did not experience the same access to educational upgrades in their credentials.

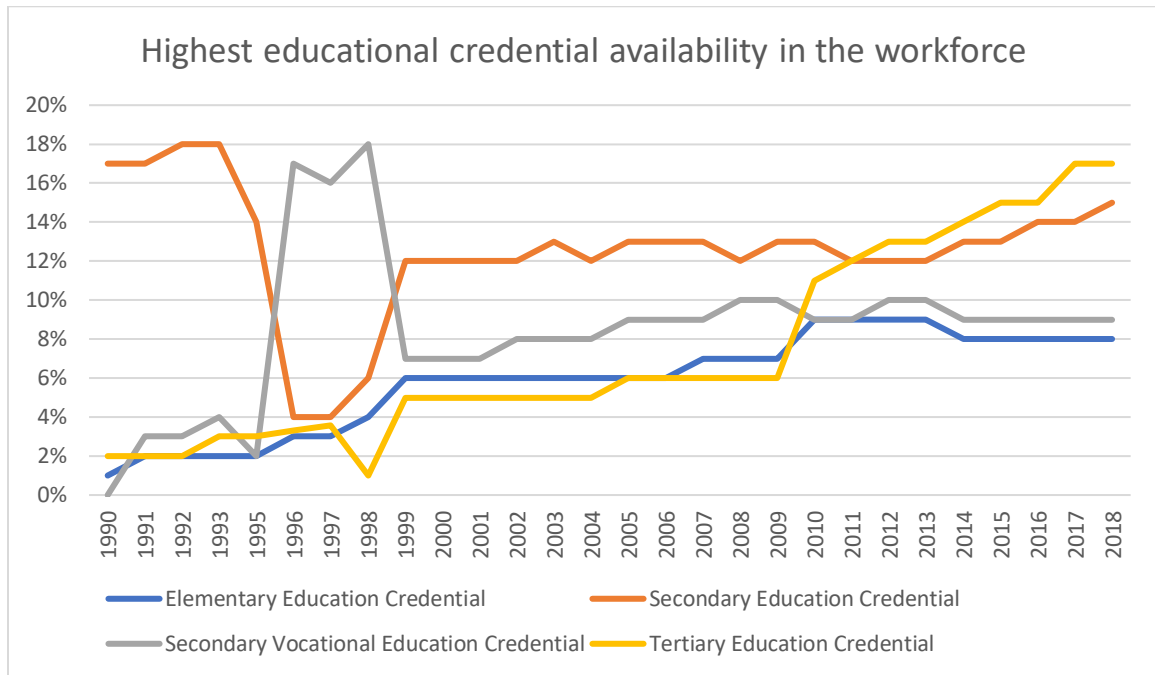


Figure 13. Educational Credentials in the Occupied Workforce. Evolution from 1990-2018.

Source: NESI

Figure 14 shows the evolution of the occupational structure between 1990 and 2018, using the grouping strategy present in the analysis of wage polarization. The evolution of the occupational structure shows three distinctive periods: 1990-1997 (A), 1998-2009 (B), and 2010-2018 (C). In period (A), the high economic growth led by the uplifting of economic sanctions and the progression of an open economy structure led to an adjustment period in workforce composition. Those changes in the occupational structure were detached from the workforce's educational attainment (see Didier (2021a)), which is explained by the advance to a services economy.

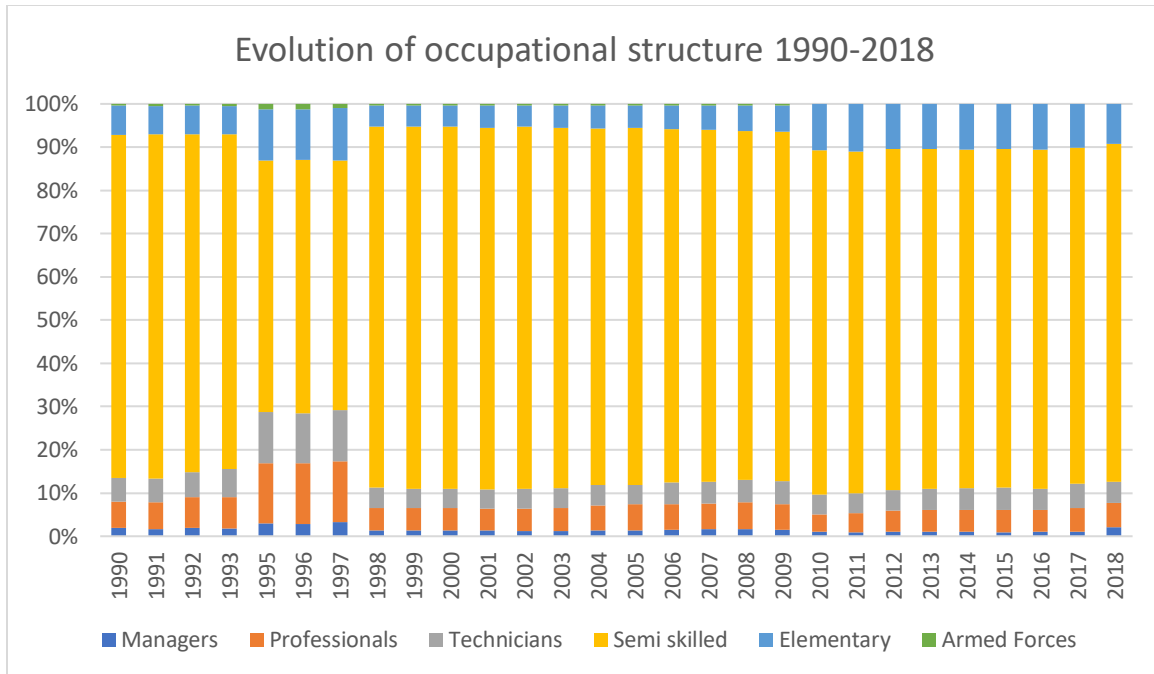


Figure 14. Evolution of the Occupational Structure of the Labor Market. Source: NESI.

In the (B) period, the occupational structure of the Chilean labor market stabilized in an almost invariant composition, dominated by semiskilled occupations and a marginal increase in professional occupations. In contrast, period (C) shows an increase in the share of elementary occupations, with stable participation of Managers, Professionals, and Technicians. That last situation could explain the differences between Didier (2021a) and Gasparini et al. (2021), where the diagnosis of job market polarization is highly sensitive to the reference period.

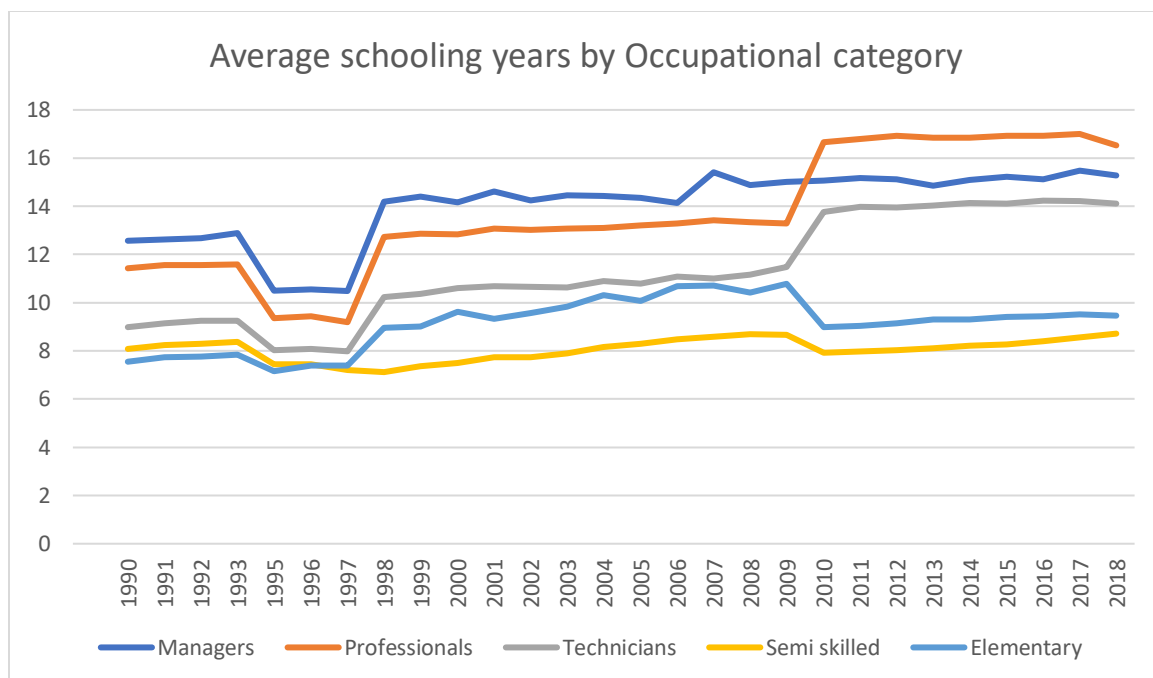


Figure 15. Average Schooling Years by Occupation 1990-2018. Source: NESI.

The difference between the periods evaluated is only one side of the story—the other side concerns educational attainment's evolution and the skill upgrading hypothesis. Consistent with previous findings from the CASEN survey, the distribution of schooling supports the idea of skill-upgrading. Figure 15 shows the evolution of the schooling years by occupation, pointing to the issue of how education-skill distribution has changed in the 1990-2018 period. Once the first cohort of students accessed higher education post-CAE implementation, technicians' and professionals' average schooling years increased, keeping stable for the semiskilled workforce and managers, and decreased a little for elementary occupations. In this case, managerial occupations have been sensitive to self-employment and entrepreneurship policies, while elementary occupations appear to be less education dependent on workers' abilities to perform those roles.

As the prior patterns showed, the relationship between education and occupations appears to follow the pathway depicted by Didier (2021c) on how the labor market

reacted to skill-upgrading. Still, the impact is absorbed by the composition of white-collar occupations (ISCO major groups 01 [managers], 02 [professionals], and 03 [associate professionals and high-level technicians]). Thus, it is necessary to unpack the general effects on those three groups, as summarized in figure 16.

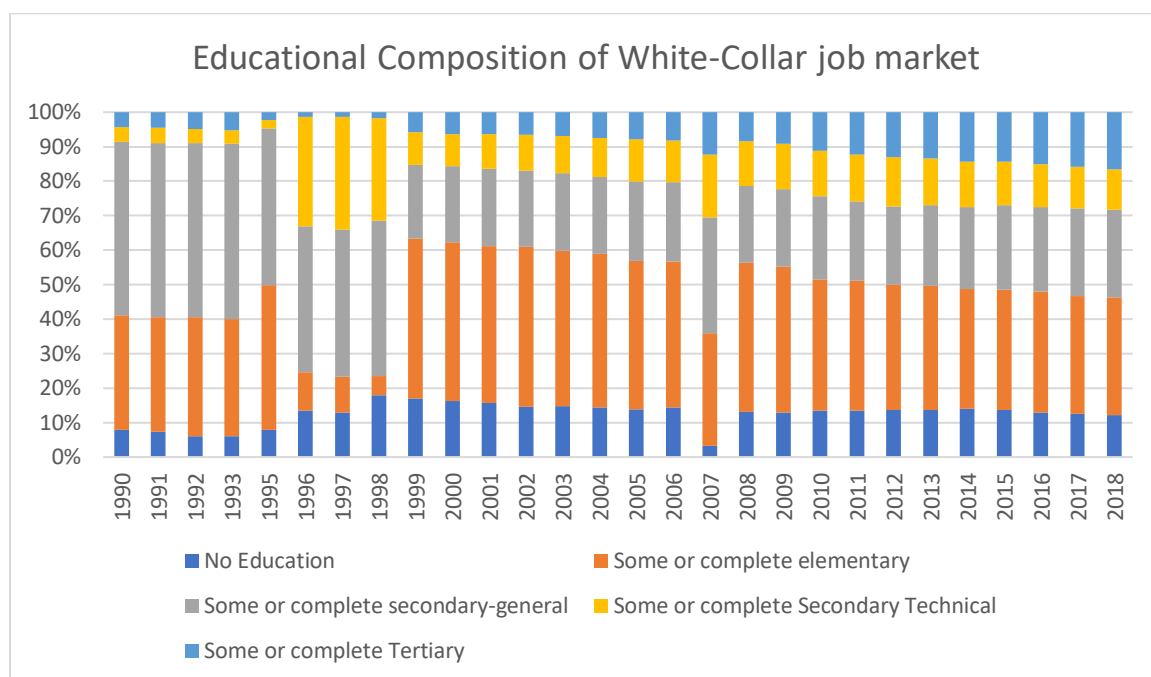


Figure 16. Evolution of White-Collar Job Market Educational Composition between 1990 and 2018. Source: NESI

The evolution of the white-collar job market composition represented in figure 2 shows a trend to decrease the share of the workforce with some or complete general secondary education. Also, it shows an increase in the share of people with some or complete tertiary education. Still, the uptrend in the participation of non-higher education levels such as elementary, secondary-technical, and non-education is notorious. Thus, the complete occupational market analysis for managers, professionals, high-level technicians, and associate professionals should be treated separately.

Figure 17 shows the specific evolution of tertiary education across managers, professionals, and associate professionals' occupations. The uptrend is evidence of a steady process of skill upgrading with a break during reform implementation.

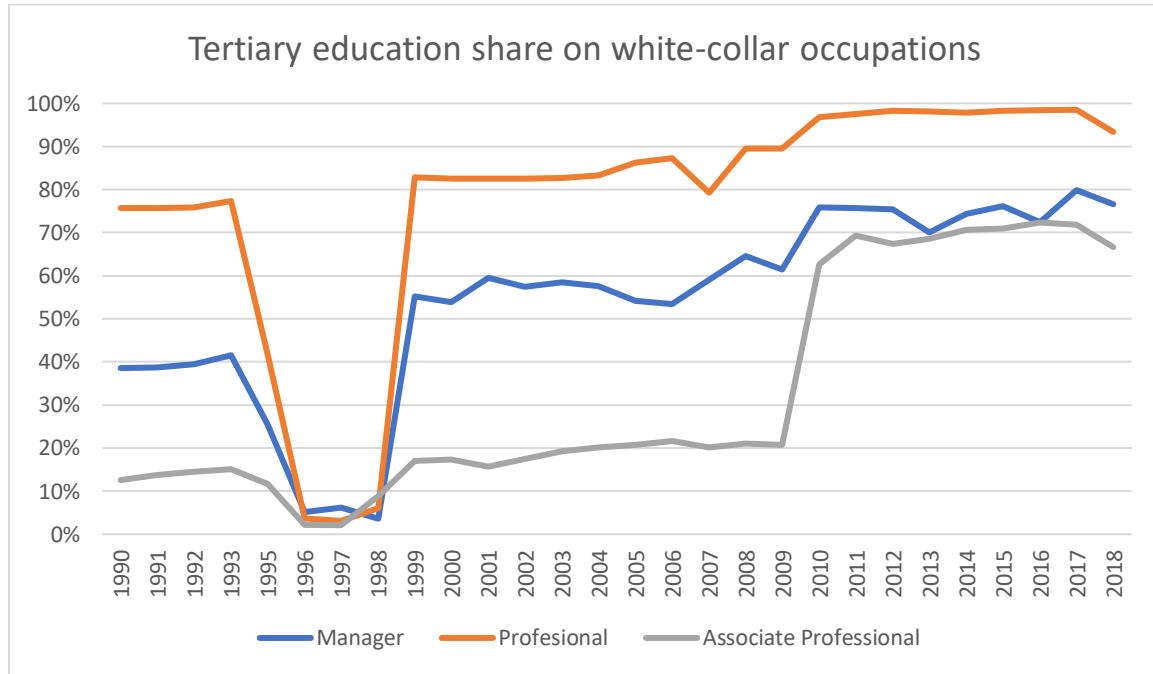


Figure 17. Share of Workforce with Tertiary Education in White-Collar Occupations between 1990 and 2018. Source: NESI

The reform opened the HVET education to the whole population; the more significant effect is found in the ISCO major group of high-level technicians and associate professionals, dramatically increasing the number of people with tertiary education studies in that occupational market.

The system dynamics analysis provides evidence that rather than experiencing an extensive process of labor market reshaping in its occupational structure, educational expansion led to a change in the job sorting strategy. The whole process led to a slight professionalization of managerial occupations, equating the entry requirements for professional occupations to hold university studies and a significant rearrangement of associate professionals and high-level technicians, increasing the requirements for

HVET degrees and pulling off secondary vocational education credentials from its participation in that major occupational group.

Section 8. Wage Distribution and Job Market Polarization

Another relevant dimension in the analysis of job polarization is the relationship between the labor market structure and wage distribution, followed by the SBTC hypothesis. Tentatively, that explanation describes the behavior of the Chilean labor market in the 1990-2018 period. According to Martins-Neto et al. (2021), the problem with analyzing job polarization in developing economies is that wage distribution is more compressed by the low-added value and the scarce presence of companies and industries that pay high salaries.

Using the Supplementary Income Survey data, I crafted the following six figures to represent the evolution of wage distribution by the occupational category, grouped by periods of 5 years. All the salaries were updated to 2018 currency, and then, given the information on the survey, I proceeded to estimate the hourly wage and then estimated the natural logarithm of that value. By that procedure, the value for each year remains comparable. As is observed through the panel of figures, there is a significant dispersion in wage distribution by each category, showing statistical differences across groups, being each category different from the others ($F_{(1,5)} = 4351261.424, p < 0.001$).

The comparison between the periods defined 90-95, 96-00, 01-05, 06-10, 11-15, and 16-18 shows a stable configuration of the labor market until 2010 (all figures are included in Panel A). In that stable configuration, elementary occupations were always in the lower tail of wage distribution, followed by the major groups of technicians and semiskilled workforce. Managers, armed forces, and professionals were the upper tail of the wage distribution. Interestingly, one of the legacies of the dictatorship process

was to set the wage structure of the armed forces over the wage of the structure for the professional job market, while on average, armed forces always present lower levels of schooling than the professional workforce (during the same period).

Despite the previous trend, from 2011, the wage distribution changed to show elementary occupations at the lower tail of the wage distribution, followed immediately by a semiskilled workforce and technicians. In the higher tail of distribution, managers, and professionals keep the same order as in previous years. That wage distribution is consistent with the evolution of the educational composition of the occupations reported by Didier (2021a). In this case, the conditions of skill upgrading in the labor market could be met. Still, following that hypothesis would require further exploration.

PANEL A: Evolution of average wage by occupation 1990-2018

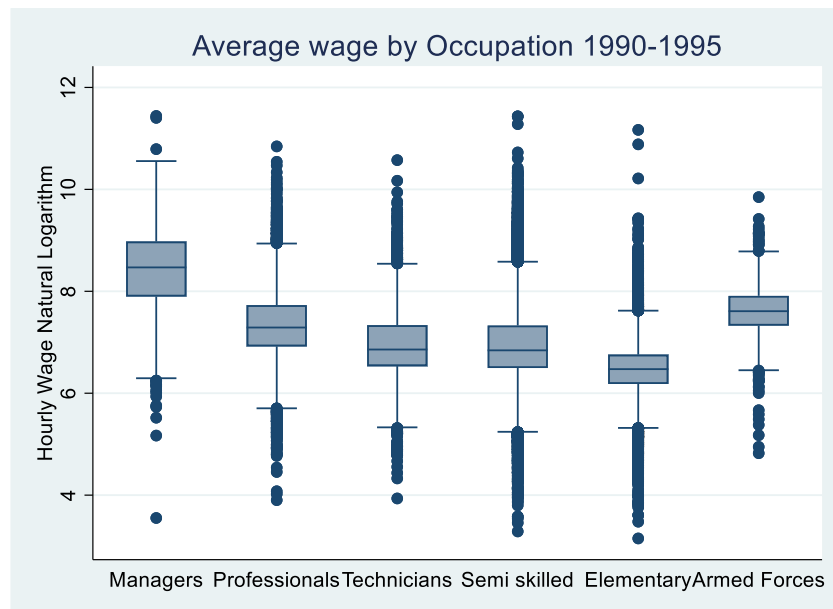


Figure 18. Average Wage by Occupational Group 1990-1995. Estimates from NESI.

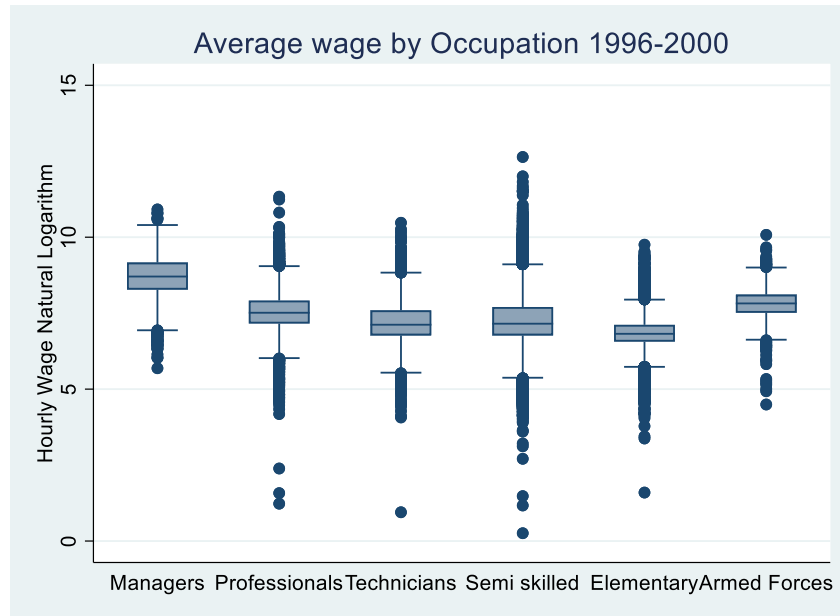


Figure 19. Average Wage by Occupational Group 1995-2000. Estimates from NESI

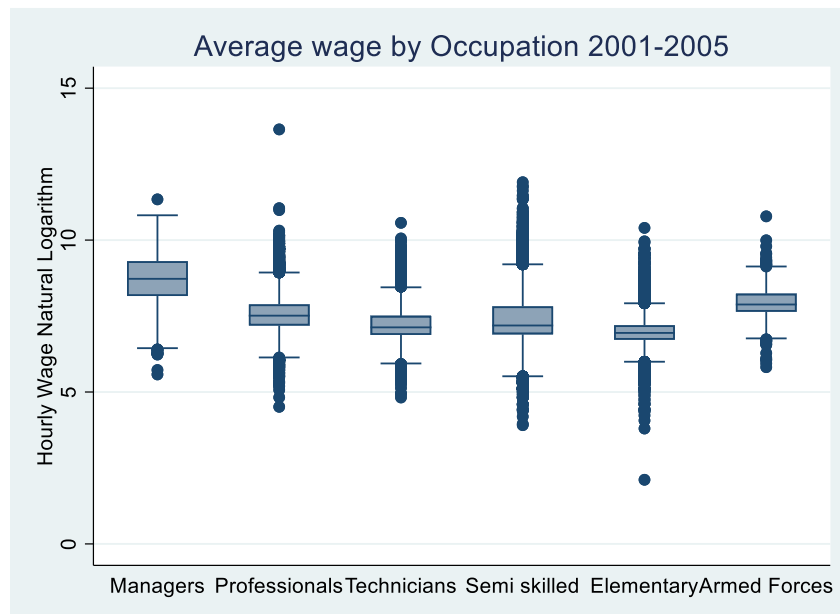


Figure 20. Average Wage by Occupational Group 2001-2005. Estimates from NESI

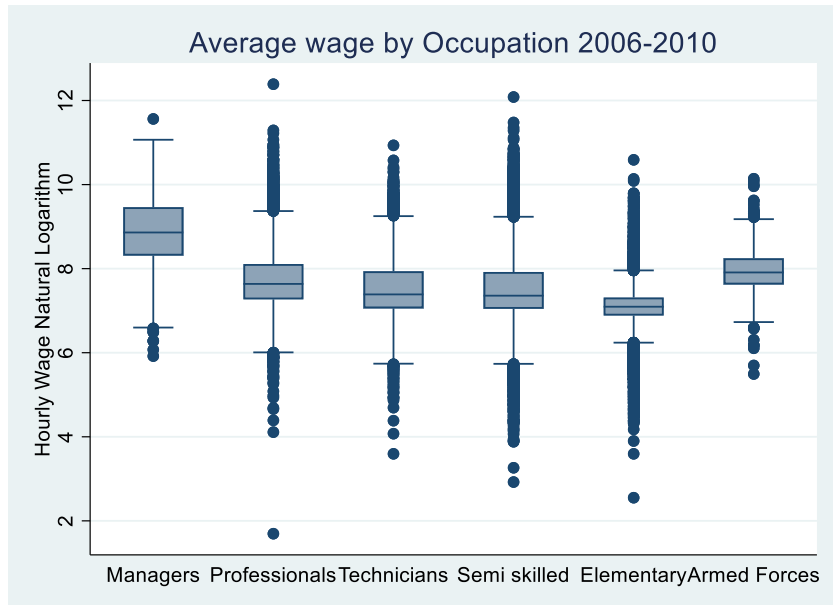


Figure 21. Average Wage by Occupational Group 2006-2010. Estimates from NESI.

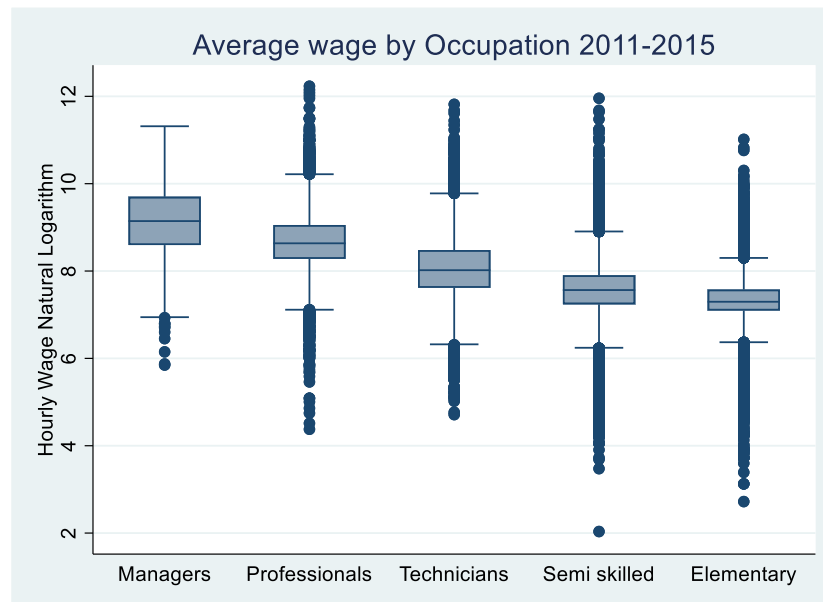


Figure 22. Average Wage by Occupational Group 2011-2015. Estimates from NESI.

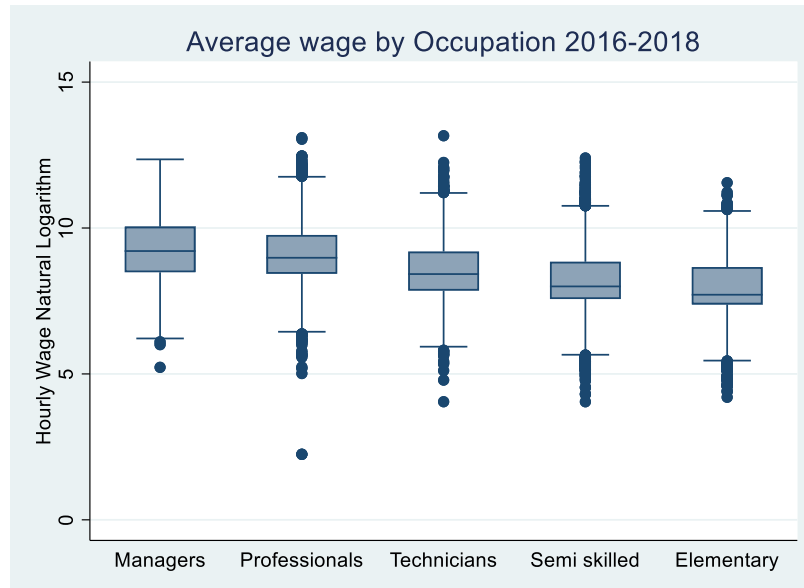


Figure 23. Average Wage by Occupational Group 2016-2018. Estimates from NESI.

While the wage distribution is consistent with occupational structure development, the question regarding possible job market polarization stands. The problem of job market polarization remains anchored to its definition: Is it a matter of wages? Or is the job market polarization an employment problem? Since wage distribution is conditioned by the occupational structure of the labor market, the categories considered as elementary or low-skilled and what is in the middle of the wage-occupation distribution turn more relevant in the definition of a polarized structure of the job market. Considering the evolution of the occupational structure and the associated educational attainment is possible to argue that the white-collar job market could be defined more narrowly or broadly depending on the level of educational attainment required to access that market. The same goes for middle-skilled jobs and the low-skilled jobs market. Figure 17 shows the evolution of an index that considers the middle-skilled job market as only technicians (JPI adjusted) and the original using the Sparreboom and Tarvid definition.

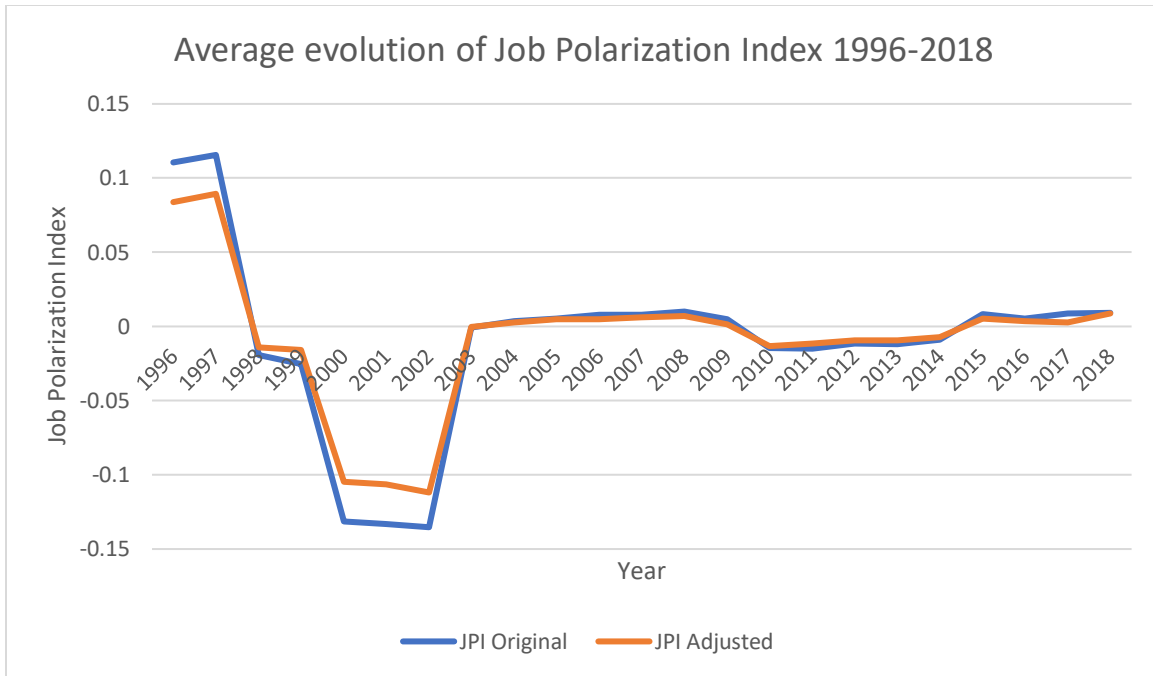


Figure 24. Evolution of Job Polarization at the National Level 1996-2018. Source: NESI.

Figure 24 shows that the index shows the same pattern regardless of the middle-skill job market definition. Still, the trend of polarization appears to define two moments: prior to and post-2003, which are consistent with the expansion of the Chilean educational system. Still, the average nationwide job market behavior uncovers the geographical variability of the labor market. While the region's average is considered and captured yearly, the index increases more than ten times its value. This approach could be more beneficial for policy analysis by providing the immediate reaction of the labor market to time-specific to capture the net effects of job creation and destruction. For comparison reasons, figure 25 shows the dispersion of the behavior of the index considering a yearly basis and regional labor market structure.

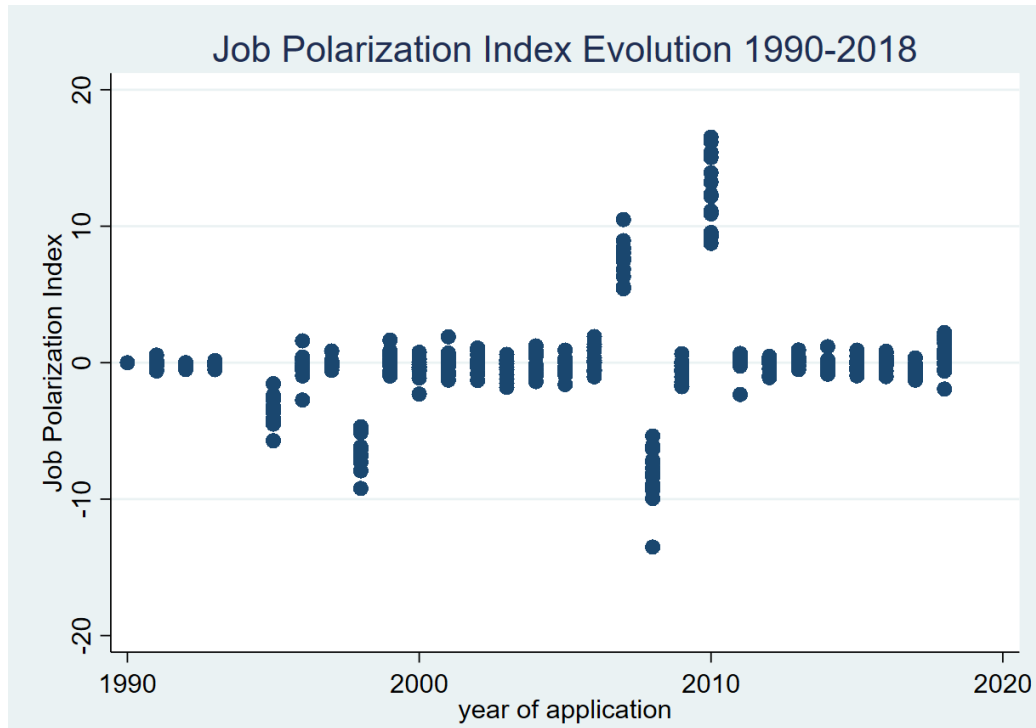


Figure 25. JPI Evolution by Region between 1990-2018. Source: NESI.

The evolution of JPI presented in figure 18 shows a similar trend to figure 14 but allows us to identify some shocks in the labor market in 1995-1997 and 2006-2010. While the 1995-1997 change could be related to significant economic growth rates during the nineties, the effect of 2006-2010 could be related to an extensive process of educational expansion (secondary and higher education). This interpretation presents some support by Didier's (2021c) analysis, where the effect of educational expansion started to appear on longitudinal data in the same period, consolidating in statistical terms from 2010.

However, the approach following the educational expansion and the change in job sorting requires another step to break with the logic of the Skill-Biased Technological Change and its ultimate impact on the polarization of the job market. This step implies connecting the general skill-upgrading process with educational returns and the change in the wage distribution.

Section 9. Wage Distribution and Educational System Expansion

In a preliminary analysis of educational mismatch effects on educational returns in the labor market, Didier (2018b) showed a consistent trend of increasing educational returns in white-collar occupations and a stagnation of educational returns for the semi-skilled and unskilled workforce. Those results resemble how the SBTC hypothesis relates to the increasing levels of inequality through job polarization. Still, the evidence reviewed until this point suggests that other phenomena took place: the expansion of the educational system and the change in the job sorting strategy for the white-collar job market.

In section 7, I provided evidence on how the educational composition of white-collar occupations changed, increasing the related credentials and overall human capital accumulation. At the same time, the analysis of occupational structure shows that the causal mechanism that connects technological change with job market polarization through RBTC could not be appropriate due to the minor change in the share of semi-skilled occupations. While in section 8, I showed how the evolution of the wage distribution related to the occupational structure resembles at least one dimension of job polarization: the compression of wages in blue-collar jobs as a secondary market and an uptrend for white-collar jobs. Can the educational expansion shed light on this matter? Could the process of skill upgrading explain regardless of the trigger of technological change?

I used equation (1) to depict the association between educational credentials and schooling years with workers' wages for illustrative purposes. Since the results are correlational, the information provided allows an understanding of the evolution of the patterns across time rather than providing causal connections between educational

attainment and wages. To present the information, first, I will explain the evolution of credential valuation and then focus on the relationship with schooling years.

For the first step, the analysis considered the valuation of any educational credential in the total labor market without distinguishing between occupations but controlling for the highest educational level attained (complete or incomplete). As figure 12 shows, before 2010, the additional value of finishing an educational level and getting a formal credential had a stable positive relationship with wages around 12 and 16% as a sheepskin effect. However, from 2010 Chilean labor market started to show indifference to educational credentials, showing no relationship with wages between 2010 and 2017, even being negative in 2018.

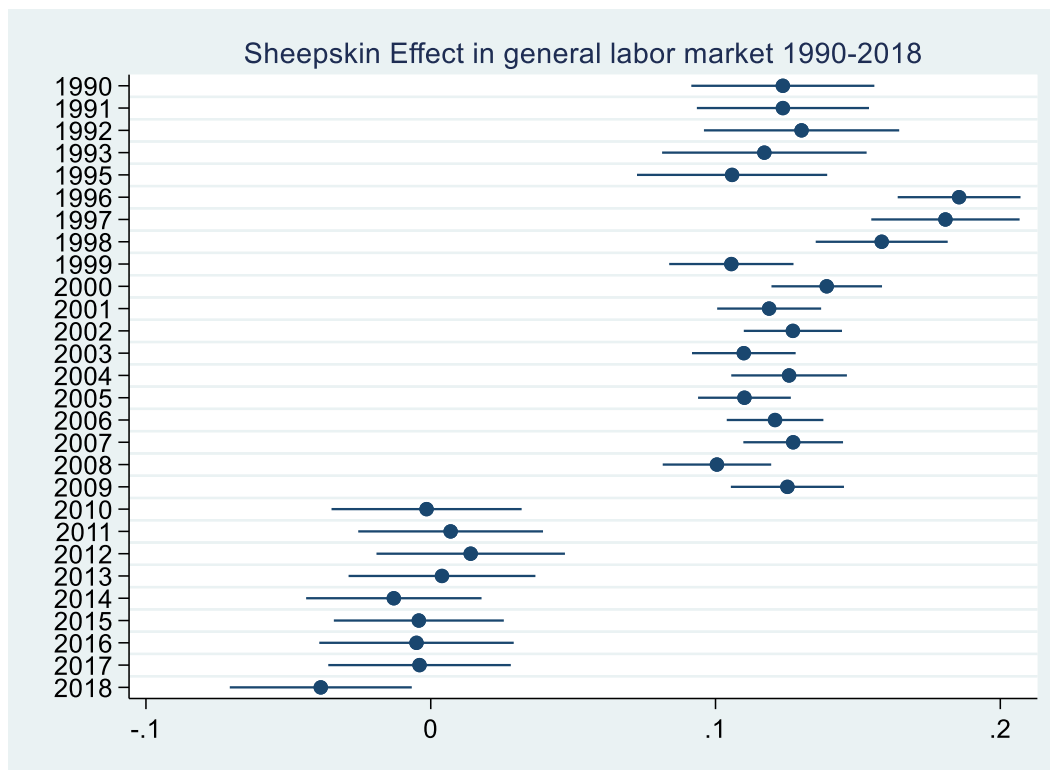


Figure 26. Sheepskin Effect in the General Labor Market 1990-2018

The pattern shown in figure 26 expressed a trend consistent with a delayed impact of human capital stock on labor market pricing strategies (see Didier (2021c) for a

discussion on sensitivity analysis and educational expansion timing). Still, this general sheepskin effect does not provide a clear landscape of the different educational credentials present in the market. For that reason, the model was re-estimated by jointly including each type of credential (elementary, secondary, vocational, and higher education). Then, the base category for credential valuation is people who did not begin or finish their studies, controlling for the schooling years and the educational level (complete or incomplete). Figures 27, 28, 29, and 30 illustrate the time dynamic of the sheepskin effect for each kind of credential across time.

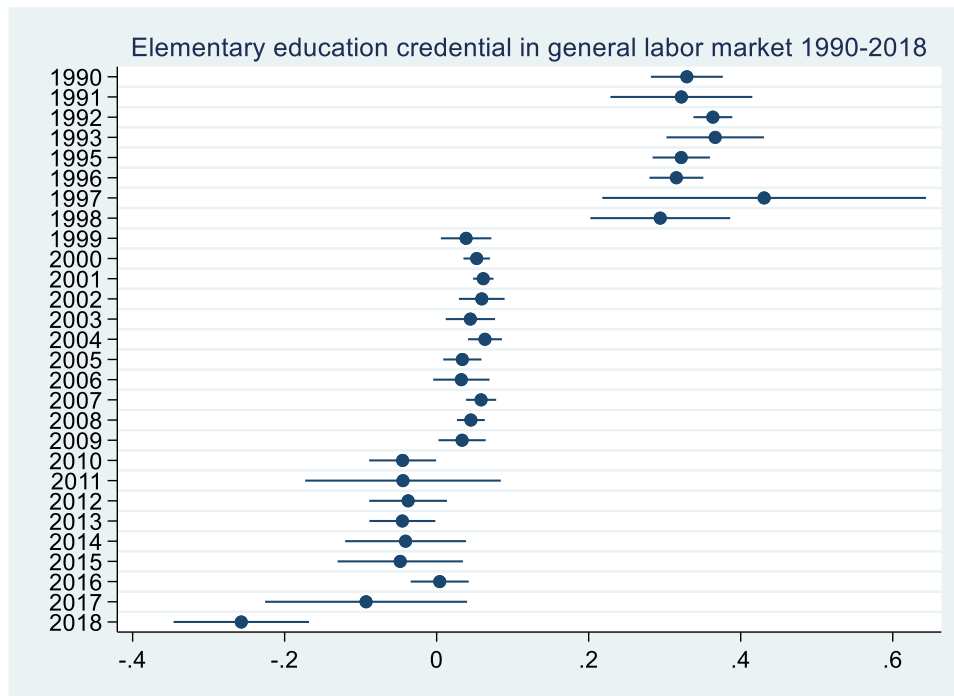


Figure 27. Elementary Education Sheepskin Effect 1990-2018

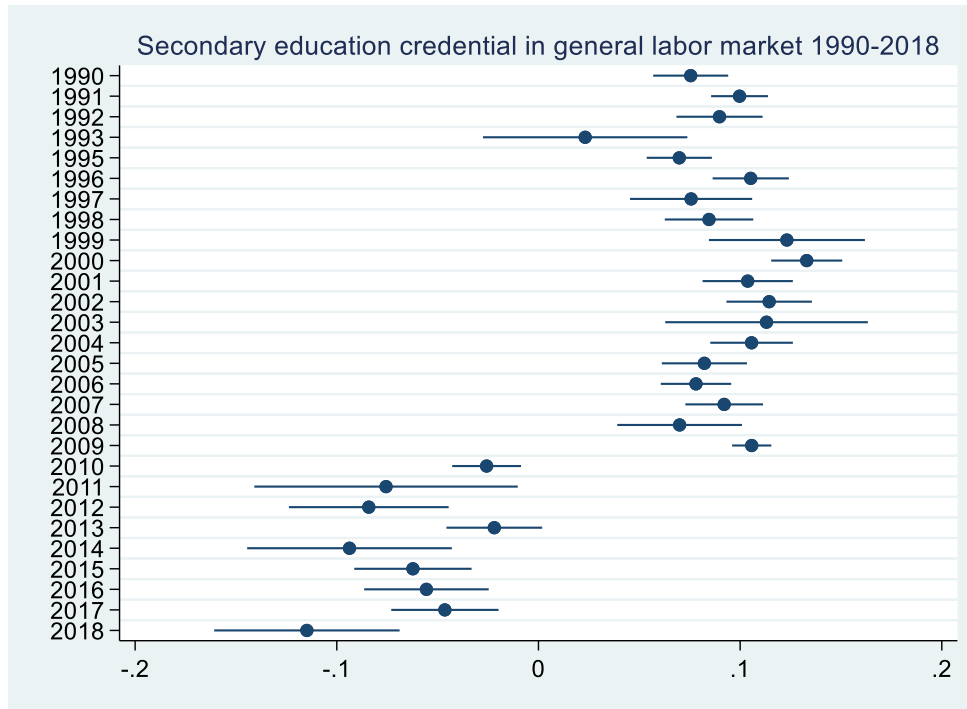


Figure 28. Secondary Education Sheepskin Effect 1990-2018

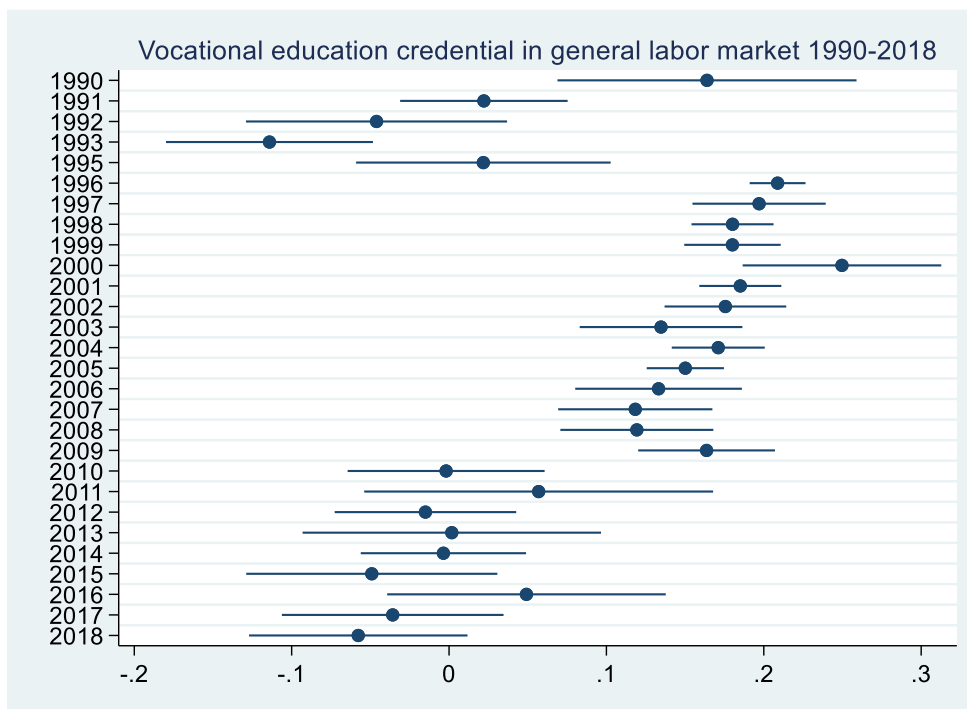


Figure 29. Secondary Level Vocational Education Sheepskin Effect 1990-2018

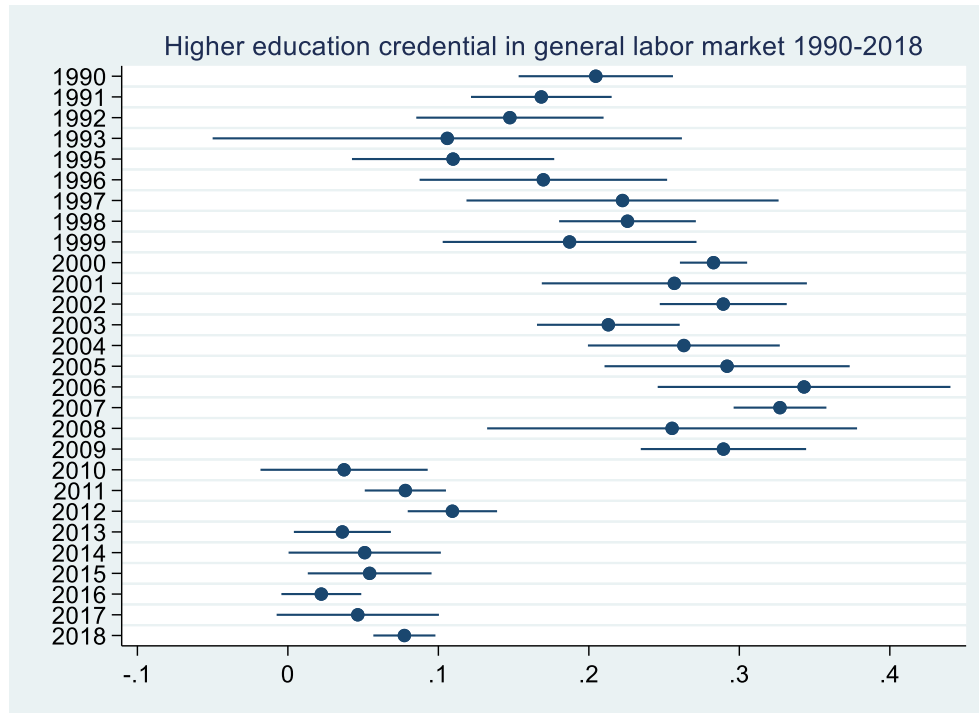


Figure 30. Higher Education Sheepskin Effect 1990-2018

The results shown in the figures by each kind of educational credentials express four different stories regarding how the sheepskin effect evolved in the assessed period. In the case of elementary education, until 2009, having finished the first eight years of schooling provided an edge in the labor market compared to those who had not finished their studies or did have access to formal education. However, since 2010 the labor market began to show indifference about that credential showing a non-significant or negative sheepskin effect. In the case of secondary education, the labor market has shown the same dynamic as elementary educational credentials: positive valuation until 2009 and then a significant negative valuation of that kind of credential.

Educational credentials have shown a decrease in their relative value regarding vocational education and higher education. In the case of vocational education, this kind of credentials shows an unstable valuation from the labor market. In 1990 the relationship with wages was positive. In 1991-1992 the relationship was non-

significant, then in 1993, it was negative. From 1996 until 2009 was a consistent positive sheepskin effect, and from 2010 the sheepskin effect was non-significant until 2017. In 2018 the sheepskin effect was negative (at 10% of significance. Concerning higher education credentials, the sheepskin effect has always been positive and significant for the Chilean labor market but decreased from 20% in 1990 to 8% in 2018. The significant variability in higher education credentials could be explained by summing in the same category higher-level vocational education and university studies (undergraduate and graduate programs).

Regarding the evolution of schooling years relationship with wages, figures 31 and 32 show the evolution of the educational returns for the general labor market and the white-collar job market. As can be observed, although statistically significant associations were present between 1996 to 2009, the magnitude was around 0.01 to 0.04%, small enough to consider that the overall relationship of credentials was more relevant than schooling years in wage-setting until 2009. The same occurs with the white-collar job market. Each additional schooling year from 2010 to 2018 was related to an increase in workers' wages between 2.8 to 3.6%.

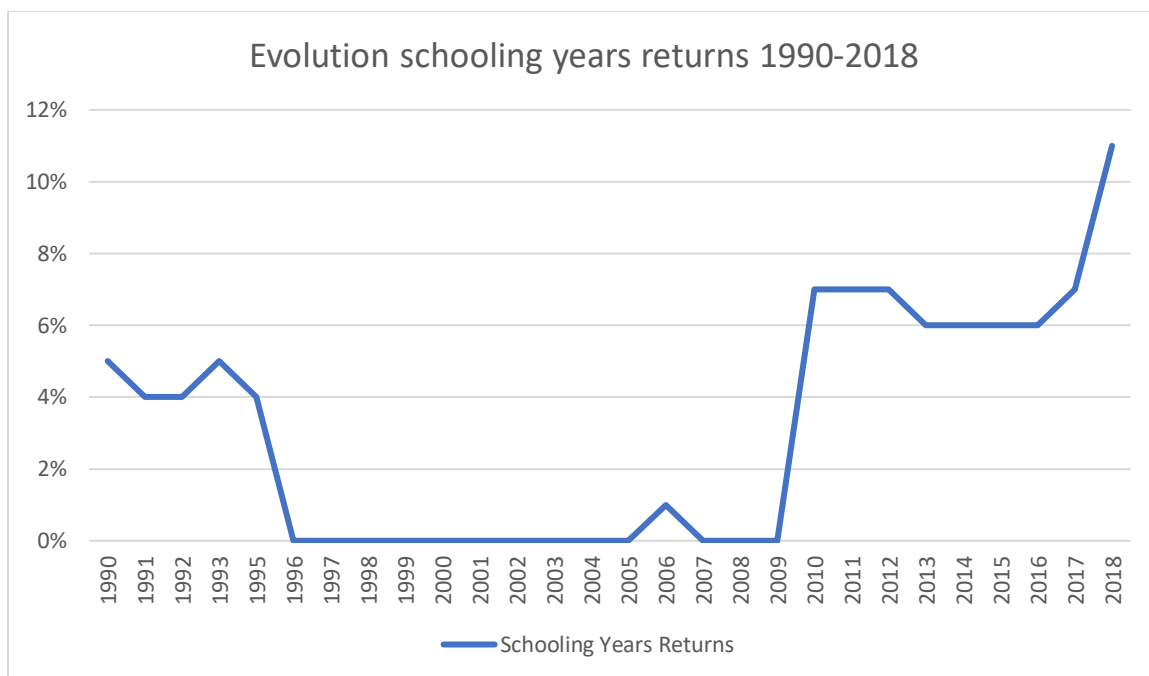


Figure 31. Evolution of Schooling Years Returns in the General Market 1990-2018. Estimates from NESI.

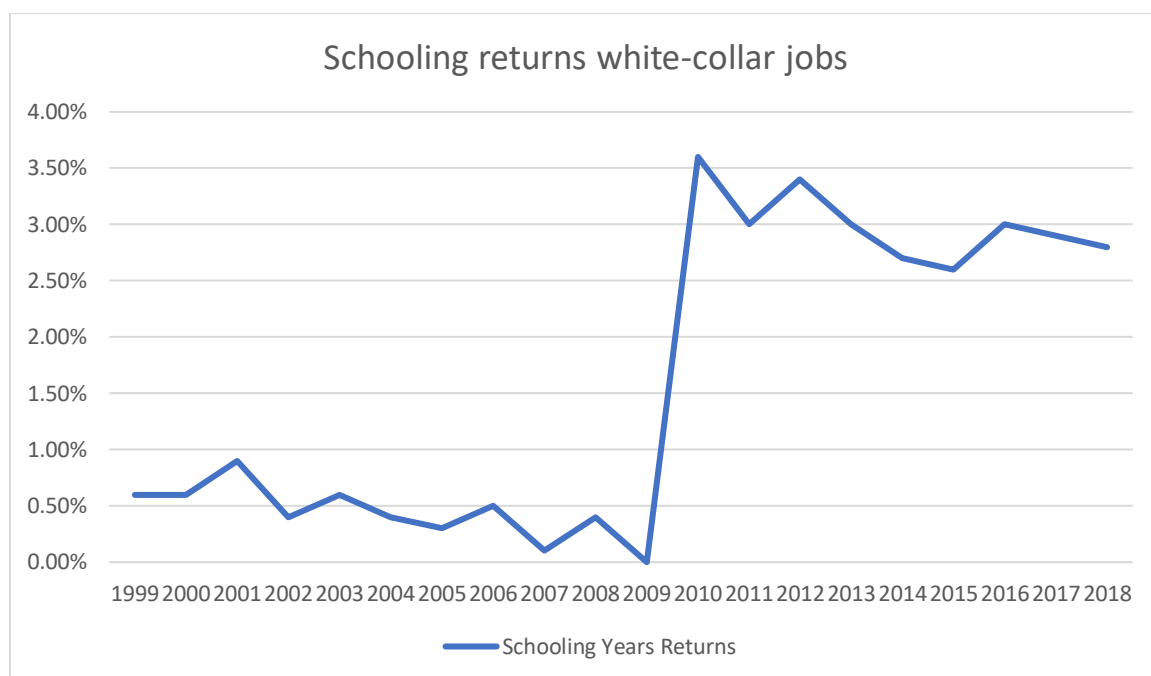


Figure 32. Evolution of Schooling Years Returns in the White-Collar Job Market 1990-2018.

Estimates from NESI.

The data from the general market and specifically from the white-collar job market shows a shift in the magnitudes between schooling years and credentials relationships with wages since the timing effect of educational expansion from 2010. That would imply that the increased availability of higher education credentials decreased their overall face value. At the same time, the market started to increase the premium for schooling years as a representation of the continuum process of skill upgrading and evolving adaptation to higher levels of human capital accumulation.

Section 10. Concluding Remarks

Prior sections have shown different phenomena that could explain the polarization of the Chilean labor market. Although the different factors have not been tested

through econometric modeling, this chapter offers a narrative of the evolution of the labor market and related phenomena. The whole narrative does not fit the overarching definition of developed nations' process, showing limitations in equivalence between the Chilean experience and the literature.

Regarding the economic cycle approach to job polarization, the analysis of central bank data on economic performance has shown that Chile has not met the conditions for a "jobless recoveries analysis." The global economic crisis in the literature did not significantly affect economic growth to fulfill the criteria of two or more quarters with negative performance to analyze the employment recovery from an economic crisis. Interestingly, the data point to a more stable configuration of the labor market, with few shocks on the employment matrix. However, since the data was prepared to be equivalent across time, some variations on ISCO and ISIC classifications could have been overlooked in favor of a more parsimonious analysis (e.g., three major revisions of ISIC and one major revision on ISCO classification).

The global chain values and the impact of free trade on economic organizations play a significant role in the evolution of the Chilean economy. The deindustrialization process has a different starting point than in developed countries, but in the long run, the industry and manufacturing activities decreased alongside agriculture as relevant economic activities. Free trade agreements have aligned the production matrix to a more straightforward structure for goods production, moving the occupational matrix to a more service-oriented configuration. This transition to a service economy and the decline of industry participation in GDP are related to educational attainment and possibly affect the performance of educational investment in the long run. In this sense, offshoring industrial employment seems less likely than simple deindustrialization by the low demand for elaborated products.

The traditional wage polarization approach to defining labor market polarization seems inadequate to describe Chilean labor market evolution. Consistent with prior research, developing economies face more compressed wage distributions over time. That could explain the marginal differences between occupational wages in the assessed period and even the restructuring from 2010 on what can be defined broadly as the blue-collar market (not credential-based employment). The distributional analysis of wages could be paired with the occupations' share of labor market employment, showing a consistent relationship between more complex occupations (managers, professionals, and technicians) with higher wages and greater levels of skills-education accumulation (especially from 2010). Since more complex occupations (white-collar jobs) are less prevalent, some wage polarization still could be found in the labor market.

The occupational approach to job polarization provides an interesting perspective on what has happened to the Chilean economy in the last thirty years. The data analyzed showed that the occupational structure changes had been light compared to developed countries' experience. Still, the increased educational attainment in the workforce could have changed the rules of workers assigned to occupations (job sorting), being more restrictive for professionals and technicians than in other occupations. Similarly, the increase in human capital stock seems to have affected the occupational and wage-occupation structures. That effect can be found in 2010 and opened several questions regarding the assignment mechanisms of the labor market to occupations.

What does job market polarization mean in Chile's context as a developing economy? The analysis shows that polarization is more a process than a state, being highly sensitive to policies regarding the labor market and industrial performance. Polarization effects could appear mildly compared to developed countries but include

relevant issues on the job market, such as competitiveness and completeness, the connection with changes in the industry structure, occupations, and how the market rewards the workforce's skills. Still, little evidence links the technology component to the polarization process, showing a skill-biased evolution of wages without significant changes in the occupational structure.

Alternatively, the labor market polarization at a national level could cover regional employment dynamics. In the Chilean case, regions present a distinctive economic structure from the available natural resources. The regional level of analyses could offer a different perspective on the consequences of extensive processes such as migration to a service economy, deindustrialization, skill upgrading, and changes in the occupational structure.

TOWARDS JUST LABOR TRANSITIONS: WORKFORCE POLICIES IN TIMES OF TECHNOLOGICAL CHANGE

Section 1. Introduction

How do we cope with the challenges of technological change? Regardless of the position and nature of the decision-making agents, it appears evident that the advances of the fourth industrial revolution are carrying -and will carry even more- changes in labor market demand and reward human capital accumulation. Whether the forecasting could be more or less accurate given the considerations regarding the institutional context and national economies structures, the mainstream assumptions consider human capital endowments as a critical variable to uptake the opportunities for economic growth and increased efficiency. In this sense, the role of human capital turns into an urgent matter of designing and implementing workforce policies that allow the system to develop the capacities required by the evolving context of the digital economy.

From a policy perspective, the documented processes associated with the development of the prior industrial revolutions -with their specific technologies- allow us to link the process of technological change to some recurrent phenomena such as technological unemployment, the change in occupational demand, technological-related job destruction and job creation rates, human capital obsolescence and destruction, and significant disruptions in the marginal contribution of labor to the production process. Although those phenomena have been subject to cross-country variability, they have been related to the long-lasting patterns of increasing inequality

reported worldwide (Alvaredo et al., 2019; Anthony Barnes Atkinson, 2013; Piketty & Zucman, 2014).

While policy development depends on social and public values expressed as social preferences regarding social inequality, the pace of the current technological change is tensioning policymakers to develop a contingent response to the current and forecasted challenges of the fourth industrial revolution. Here, the speed of change and response is not a trivial matter expressed as an opportunity window for policymaking (Kingdon, 2014), especially concerning economic growth for developing economies (Perez, 2015). A timely response would allow countries to get the benefits of increased efficiency in the use of resources, expansion of sectors across national economies, and redistribution of social welfare, revaluing the contribution of labor in ample spaces of the labor market (Perez, 2004; Perez & Schäfe, 2021; World Economic Forum, 2021).

This chapter aims to reconcile evidence and problem models for workforce adaptation by developing a micro-macro approach to connect principles for policymaking and the logic of companies and organizations for their human resources policies. However, the enterprise of policy design and implementation is subject to the great uncertainty of the appropriateness of policy tools, availability of evidence, and the lack of clear understanding of the intended labor dynamics and overall national economic productivity. I will structure the discussion by approaching the problem of workforce adaptation through the social value of justice as a lens to observe and analyze the phenomena.

The rest of the chapter is organized as follows: section 2 presents a brief depiction of the process of the technological adaptation process. Section 3 presents the macro approach considering the principles to develop just labor transitions, including situational, feasibility, and capabilities-oriented interventions. Section 4 presents the

logic of just labor transitions grounded in the organizational justice tradition and considers its informational, distributive, interactional, and procedural subdimensions. Section 5 problematizes workforce adaptation policies from a just labor transitions perspective, entangling the macro and micro approaches. Finally, section 6 concludes by proposing recommendations to develop policy agendas based on adopting the challenges of the fourth industrial revolution.

Section 2. A Brief Depiction of the Technological Adaptation Process

The prior discussion regarding technological change's effects on the labor market has shown that technological adoption's evolution covers labor demand and wage-setting strategies. While the concerns about fairness in the overall sociohistorical process have been a matter of examination through the skill-biased technological change (Autor et al., 2003) and routine-biased technological change (Goos et al., 2014), the problem of wage-setting from an organizational level perspective appears to be detached from the discussion, neglecting a relevant area of interaction between the labor market and individuals adaptative strategies. If social cohesion is a relevant concern, governments and organizations should consider both sides: the macro and micro levels of fairness during technological change.

Figure 33 shows a summarized version of the interactions between the macro and micro levels, considering the interplay between the general dynamic of the labor market, organizations' strategies, and individuals' career strategies.

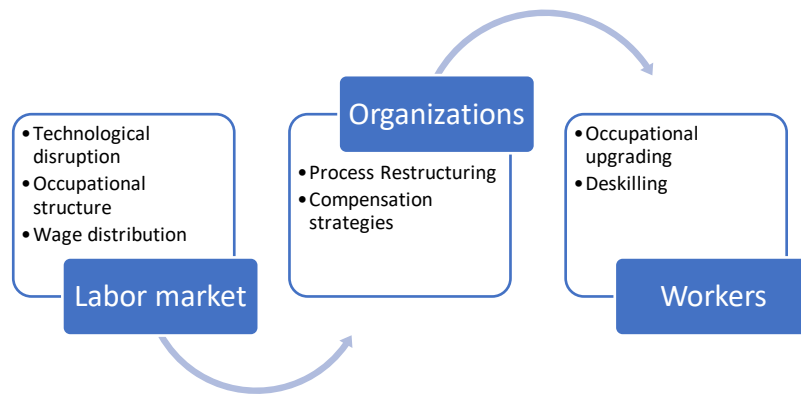


Figure 33. Dynamics of Technological Adaptation

In a brief depiction, the dynamics of workforce adaptation are triggered by a technological disruption that appears to be relevant and valuable for organizations' goals (i.e., efficiency, efficacy, production outcomes). Organizations start the process of technological adoption by restructuring their production process and reorganizing the value chains in direct consideration of the potential of new technologies. Consequently, workers' roles are redefined to fit the envisioned value chains and production structure, leading to job enrichment (or occupational upgrading) or job downgrade (or deskilling). Both alternatives change the organization's wage distribution and alter the material basis of labor relations. Consequently, in the long run, workers must make career decisions considering the change in the relative value of their jobs, the relative value of their skill sets, and their human capital investment strategies. The continuum adjustment between employers and employees creates the features defined as the change in the wage distribution and labor market occupational structure.

Which is the place for justice in the overall process of technological adaptation? The organizational and labor market logic presses workers' career strategies in dealing with the changes in the labor demand, which entangle economic discussions regarding

leisure-consumption preferences and subjective dimensions such as job satisfaction and social welfare. From here, it is possible to differentiate the macro and micro levels in the discussion, whether by considering the government response to technological change or the organizational response during their processes of technological adoption. In the following sections, I will present both dimensions of response and a theoretical synthesis to develop a proper policy response to the challenges of technological change.

Section 3. The Macro-Approach

3.1 Justice as an Imperative

The starting point for policy design and development in the case of workforce adaptation is to situate policy tools and problems in the context of the continuous process of technological change, considering social memory and learning. Whether different societies reacted and adapted in diverse ways to the whole process labeled as "technological change," in the long run, early and late adopters have converged into a similar situation in which social cohesion and economic inequality conflict. That situation has been primarily represented in sociological and political science research on the topics of "globalization losers" (Lamp, 2019; Lechler, 2019) and socio-political polarization (Chiang et al., 2019; Duca & Saving, 2021; Winkler, 2019). In both streams of literature, changes in countries' economic structure (i.e., the relevance of agriculture and share of industrial activities) altered social relations and socioeconomic structure, stressing groups' identities and social capital dynamics.

In a broad sense, the different mechanisms that explain social bonding have shown strong ties to countries' economic performance (Pervaiz & Chaudhary, 2015; Ramazzotti, 2010; Wallis et al., 2004), articulating the convergence, relevance, and

impact of education as a factor for economic development (Gradstein & Justman, 2001; Mickelson & Nkomo, 2012). In the wicked dynamic of winners and losers, social cohesion is a relevant element for economic growth. Still, the social outcomes of the third industrial revolution -an increase in social inequality and social vulnerability for some groups- negatively affect social cohesion (Vergolini, 2011a, 2011b) and, later, the prospects of future economic development or growth.

In this context -and by the learnings of the third industrial revolution- it is a matter of public interest how to ensure access to the benefits of technological change and prevent possible negative externalities from technological adoption. The blueprints of the 3IR and its depicted dynamics lead the attention to human capital accumulation as the basis for a workforce adaptation strategy foresighted by international organizations (i.e., WEF, OECD, ILO, UN). Still, institutional factors such as educational, labor, trade, industry, and migration policies that played a significant role in the past seem again relevant. In this sense, avoiding the documented and forecasted effects of deskilling on large sections of the labor markets could be a mind strategy to protect and enhance social cohesion across societies.

3.2 Justice as a Principle for Policymaking

What are the implications of taking a justice approach to workforce adaptation policies? In simple terms, it implies considering the forecasted scenarios of the fourth industrial revolution development, the series of factors responding to national idiosyncrasy (i.e., institutional setting), the evidence regarding the effectiveness of policy tools, and how those elements could affect the implementation of national strategies to cope with the negative externalities of technological change. Those elements would intermix with the public values orientations of policy entrepreneurs

and policymaker's systems, allowing the articulation of public and private resources to develop and implement the required policy solutions.

Although different countries will have different values and public sphere priorities (Inglehart, 2015), the connection between social cohesion and economic performance allows us to focus on a normative concern: how can the government avoid or moderate the negative externalities of technological change? At least in the value layer of policy design, the response corresponds to the concern about social equity and public administration's role in realizing and promoting such value. At this point, policy agendas will be grounded on social preferences regarding inequality (Johnson et al., 2006; Klimm, 2019) and the possibilities of a widespread effect of technological change externalities across society.

While justice -as a principle for policymaking- is a vague notion in this context, tensioned by inequality perceptions and the classic definitions of the role of government (Rawls, 1999; K. B. Smith & Larimer, 2009), it has a specific application to the workforce adaptation problem. Given the rationale behind the current problem of technological change -which threatens to increase the current levels of inequality and, therefore, decrease the levels of social cohesion – justice as a principle for policy design could alleviate the negative externalities by promoting the use of some sets of policy tools. However, the concept's vagueness could hinder its application to the policy development cycle. Thus, I will propose three major principles to wrap up the policy and economic discussions regarding the role of government in this process: the situational, feasibility, and capabilities principles.

The situational principle is based on how the rational connections between past and future structure the current narratives of technological change, bringing imaginaries and social representations of the process of technological change and its possible outcomes. Suppose the analysis follows the assumptions and learnings of the effects

of the last industrial revolution. In that case, the policymaking process should be fueled by the national expressions of those processes rather than the mainstream understanding based on the stylized facts regarding technological change. This understanding of the suitability of policy tools to the problems' nature will derive from adjusted expectations about how those policy tools would interact with the institutional setting and dynamics of labor and educational market coevolution.

Although generic recommendations such as WEF's reskilling revolution are compelling by their simplicity and straightforward rationale connecting specific skills with the forecasted demand, it is not neglectable that the system's capacity to process the adjustments in the labor supply and demand will significantly vary across countries and sub-national economies. The feasibility principle entangles the problem of the degrees of freedom that governments, individuals, and organizations have while dealing with the process of technological change. In a broad sense, the systems dynamics and national conditions will constrain the possibilities of workforce adaptation by setting agents' efforts inside a specific set of alternatives, including the relative value of skills and competencies, their availability, and provision/creation mechanisms.

The last principle considers applying Sen's (1993) capabilities approach to workforce policy design and implementation. According to the formulation of the approach, policy -or governmental action- should aim to allow the population to achieve their subjective well-being through access to the means to accomplish their preferences. In this regard, once access is universal or widespread, it would be the role of individuals to uptake measures to engage the problem of technological change on their own accord, based on their preferences and endowments. As a normative approach, this perspective allows structuring a policy response through strategies

entangling a change in the availability of the means for workforce adaptation, including active labor market and educational policies.

Section 4. The Micro-Approach: Organizational Justice

While the three principles presented to bring a justice dimension to workforce adaptation appear to be a general concern, policy development should consider a micro approach to enact those normative concerns to ensure practical guidance for design and implementation. Rather than developing an overarching theory of justice, I will engage in the discussion using organizational justice theories to connect human resources and companies' strategies to the decision-making process.

Organizational justice covers several ideas, attempting to balance how individuals perceive fairness in the treatment by organizations (Colquitt, 2001; Moorman et al., 1998). The concept has been connected with sensitive issues in organizational behavior such as job performance, job satisfaction, extra-role behaviors, and ultimately organizational performance (Bashshur & Oc, 2015; Burney et al., 2009; Fassina et al., 2008). While empirical research has taken several approaches to understand the dimensionality of organizational justice, the typical approach considers at least four dimensions: distributive, procedural, interactional (interpersonal), and informational. Those dimensions cover distinct sources of differential treatment of employees by organizational procedures and hierarchical relationships.

In terms of the historical development of the concept, the distributive dimension is grounded in early developments of equity theory (Adams, 1965). It aims to represent the employee's reaction to how rewards are distributed in the organizations, including the monetary and non-monetary dimensions of compensations at the equity-inequity judgments regarding organizational strategies (Schminke et al., 1997). The procedural dimension appeared later and considered that even if there are inequality issues in

distribution, the reaction to those perceptions was tied to the perception of justice in the reward-setting procedures (McFarlin & Sweeney, 1992). While distributive and procedural justices rely on a structural dimension of organizational operation, interpersonal and informational justice are grounded in the social aspects of organizational life (Loi et al., 2009). In this sense, informational justice represents the clarity, accuracy, and quality of the explanations that organizations provide regarding their procedures, and interpersonal justice captures the interpersonal sensitivity shown by organization members regarding the different outcomes of the reward system (Kass, 2008).

The problem of integrating organizational justice into the process of technological adoption is strongly related to the uncertainty and variability introduced by technological change. For example, wage-setting and compensation strategies depend on the market behavior for some occupations and the demand for specific skill sets. The distributive justice dimension would require defining ex-ante the marginal contribution of labor to value creation and then defining proper strategies to deliver the rewards across the organizational system. In the case of procedural justice, the shift in job valuation demands some degree of validation from workers to the new compensation strategies, tensioning the historical perceptions of equity across the organization, redefining the personal understanding of their participation in the production process, and the agency of workers on setting their contribution to the value chains. At the same time, sustaining perceptions of care and justice regarding those elements would require a clear understanding of clear compensation strategies and communicating them effectively to workers. Without a pre-defined strategy to communicate the changes, there is a high risk of eliciting resistance to change, counterproductive behaviors, and decreased workers' commitment to their jobs, affecting their performance and overall organization outcomes lately.

Section 5. Assembling a Policy Response Model

5.1. Revisiting Stylized Facts and Empirical Results

Using the transitional model of workforce adaptation allows us to connect and describe the process of technological change considering the prior and current waves identified as the third and fourth industrial revolutions. Since the description of the prior and current processes comes from the evidence and modeling of developed economies' experience, the primary strategy followed during the previous chapters was to find commonalities and test if the hypothesis and assumptions priming the discussion regarding the future of work, future of jobs and technological adaptation were able to connect with the historicity of a developing economy as Chile.

Regarding the antecedents of the model, there are notorious differences regarding the narratives of technological change. First, the Chilean economy did not reach a structure with a relevant degree of industrialization prior to the process of workplace computerization; thus, when the last economic crisis (during the assessed period) took place, the economy migrated smoothly to a service economy without the acute effects of technological unemployment presented in other countries as the United States or the United Kingdom. Second, Chile began the massification of computers in 2005, when the international price of computers experienced a considerable downturn, and prior to that date was not a significant trend to change the occupational structure of the labor market. Third, the expansion of the educational system occurred during the 2000s as in other countries in the region. Therefore, although it could have been a trend for requiring a more educated workforce (consistent with SBTC), the endowment of human capital was low during most of the technological change process, impeding to increase in the share of white-collar jobs due to job sorting strategies based on educational credentials. Fourth, the whole dynamic of the system sustained stable

levels of economic complexity, constraining the development of larger value chains with greater levels of added value.

In the long run, the national base for labor market segmentation (or job polarization) was given by the educational system's structural expansion, increasing human capital accumulation across the workforce through specific policies. However, since the margins of change between occupational markets were slight, rather than the polarizing dynamic, the change in the educational composition of occupations shows a massive process of skill upgrading without a significant event of occupational upgrading. Therefore, the changes experienced by the labor market during the process of workforce adaptation could be interpreted as a change in job sorting, looking for a more optimal arrangement of the connections between human capital accumulation - and educational credentials availability- than a change in the preferences the demand side of the labor market.

5.2. Envisioning Just Labor Transitions

Although there is considerable variability across countries, as the comparative analysis of the Chilean case shows, the dominant approach to cope with the current wave of technological change considers the assumption of a re-edition of the prior wave regarding technological unemployment and the evolution of the labor market's occupational structure. In this sense, the human capital endowment of the workforce and career strategies appears to be constrained to the same options for occupational upgrading and deskilling alternatives for workers. Therefore, for social cohesion purposes, implementing policies focusing on justice will alleviate the problems regarding the perceptions of winners and losers, providing alternatives for workers to navigate the current stream of changes. Still, as a broad concept, justice should be operationalized for policy design and implementation to encompass the macro and micro levels described previously.

The theoretical proposal underlying policymaking for workforce adaptation is represented in figure 34. Under the national level category, the first layer considers that every policy should include the specific characteristics of their economy, labor, and educational markets institutions in its assumptions. Simultaneously, following an evidence-based policymaking approach, selecting a policy tool as active labor market policies or educational policies should be grounded in a clear understanding of their performance in the current labor market and forecasting for the intended results. However, those principles will interact with the organizational domain and their administrative procedures during technological adoption. Workers interacting with the policy and organizational system will make decisions based on available information, choosing specific career strategies according to their preferences and capabilities.

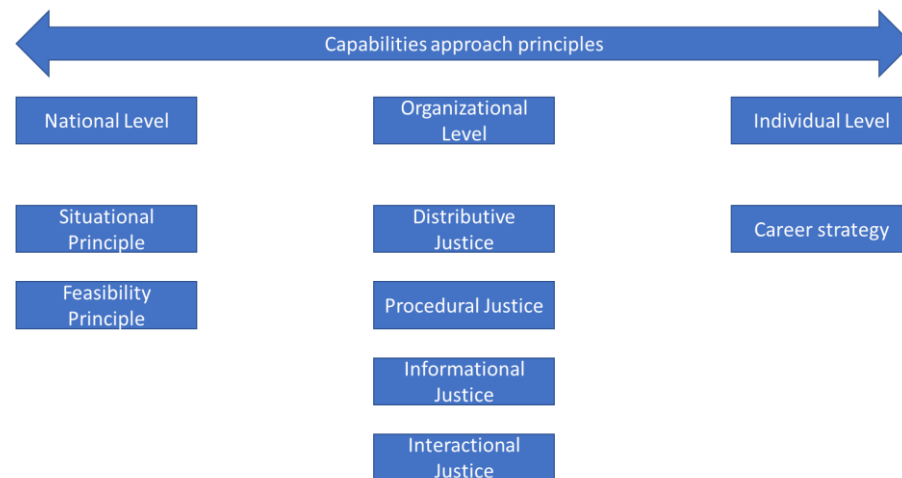


Figure 34. Just Labor Transitions Layout for Individual Career Decision-Making

In the case of Chile, the situational principle will cope with the limitations coming from the long-term stagnation in the overall complexity of the economic system, an increased share of skilled workforce, and a relevant migration to the service economy as its fundamental characteristics. Consequently, while most of the automation would take place in the mining industry (Didier & Perez Comisso, 2023), the most relevant effects of the fourth industrial revolution would appear in the margins of the service

economy, especially in the knowledge-to-digital-economy transition (Didier, 2021a). Once the main areas of the economy likely to be affected by the current wave of technological change are identified, the government can develop focalized interventions to smooth workforce adaptation.

The dimension of feasibility compels the material basis of labor relations and the characteristics likely to affect any agenda of workforce adaptation. In this case, the institutional arrangements relating to labor and educational markets, as the presence of institutional settings for policy development, gain relevance in the analysis. The problem of adaptation considers at least solving three issues: labor discrimination, institutional background for credentials, and the coordination between the government and organizations. In this sense, any attempt to implement agendas such as the reskilling revolution (World Economic Forum, 2019) will have to deal with the differential treatment of workers on their background, ethnicity, and gender.

Policy design should be sensitive to how the labor market is -and how it has treated- treating workers and develop additional tools to decrease discriminatory practices across organizations. That would imply tackling a central issue of the reskilling process: negative incentives to up-taking training should be avoided by decreasing the relative value of skills conditional to variables irrelevant to workers' performance. One alternative to avoid bias in treating workers' skills and their artificial devaluation is to craft strong and institutionally grounded credential systems (World Economic Forum, 2021). In the case of Chile, that would be the articulation between occupational certifications and licenses, training credentials, and the adequate frame for assessing and controlling the institutions involved.

Although reskilling revolution considers almost only a private-grounded initiative, its connection with traditional Active Labor Market Policies (ALMPs) is clear and direct. ALMPs as policy tools encompass several alternatives to intervene in the supply and

demand sides of the labor market (Meager, 2009), including strategies based on training activities, job placement, job guidance, and placing incentives to hiring vulnerable populations in certain moments of labor market evolution (i.e., young people, gender, ethnicity). In the case of Chile, since the training system is organized as employer-based (Didier & Cox, 2012), access to training and recognition of training credentials are a matter of public-private coordination. Thus, the government should explore the incentives for companies to engage in technological adoption and ensure that training supply is adequate to the subsequent technological-led demand for specific human capital.

At the organizational level, the problem translates into how the technology adoption process rebalances the marginal contribution of labor to the value creation and the degree of formalization of that change in the organization's wage structure. The dimensions of organizational justice are advantageous to modulate the inequity in the process by addressing specific human resources policies to communicate to workers the current and envisioned changes in the production process, the roles that would be demanded, how they would be rewarded, and what are the opportunities of workers to acquire the related skills sets. That last aspect connects the internal practices of organizational justice with the institutional layout of policies to favor workforce adaptation, being the key the transparency in the communication of the changes and the availability of alternatives for career decision-making.

In that last regard, it is relevant to point out that while the training system is structured to incentive companies' investment in workforce training to take up the benefits of the fourth industrial revolution, it is required a straightforward approach relating information, available alternatives for workers, and an institutional layout able to support the career transitions induced by technological change. The capabilities approach principle will serve as a mechanism to orient those policies, where the best

judges of individual preferences and current abilities are the same individuals. However, only by supporting access to information could workers engage their career strategies (i.e., occupational upgrading or deskilling) and understand the possible consequences for their welfare.

Section 6. Conclusions

In previous chapters, I have provided different alternatives and approaches covering the coevolution of labor and educational markets and how technology has played a significant role in defining those relationships. In this concluding section, I will summarize the main findings and theoretical discussions relating to workforce adaptation, the future of work, and the ideas behind just labor transitions.

The idea of just labor transitions combines three relevant elements for policymaking during technological change: technological (un)determinism, the situated nature of the evolution of jobs, and justice as a mean/end. Since there is extensive documentation on the historical effects in the labor market of industrial revolutions leading to technological unemployment, it is safe to argue that labor transitions are inevitable, but the adverse outcomes for individuals and households are not. Technological change can lead to adverse outcomes for some groups when there are no policies guaranteeing alternatives for individuals to adapt and thrive during the process, as the historical experience of the US and the UK compared to European countries has shown.

The mainstream approach to technological change has been developed extensively based on the historical experience of the United States and the United Kingdom, delivering the skill-biased technological change, the routine-biased technological change, and, lately, the idea of job market polarization. Literature has bridged those concepts to present a rational linear progression following a determinist path, with the

implicit assumption that the evolution of labor market occupational structure would follow the same structure across countries. While the evidence has pointed out that although there was a common trend towards increasing the wages for white-collar jobs, the dynamic of shrinking in the semi-skilled occupations has appeared to be related to specific educational, trading, and migration policies. Thus, the determinist path seems to not adjust to the experience of developed economies nor for developing economies.

An (un)deterministic understanding of the prior wave of technological change across countries brings another layer of complexity to the discussion on the future of work - and related workforce policies. Institutional variables shaped the labor market's response to the massive change in the production process caused by technological disruption. The scope and reach of the discourses and forecasting regarding the future of jobs (World Economic Forum, 2020b) should be reconsidered by adding the national idiosyncrasies as a source of variation, distorting the intended globalized perspective in a phenomenon heavily grounded in the sociohistorical conditions of each country. In other words, technology did not produce homogeneous impacts, and it is unlikely that the current wave could generate that kind of outcome.

On a related note, the pace and intensity of technology adoption should be added to the equation for national-level forecasts regarding the future of jobs. The timing of technological disruption and subsequent adoption patterns is vital to define the potential effects, not only regarding the evolution of job characteristics and labor demand but also in the overall performance of the economic system. The comparative analysis of developing economies performed by Martins-Neto et al. (2021) pointed out that financial constraints and even cultural elements are related to the dynamics of technological change, being distinctive from the factors present in developed economies. In this sense, the discussion regarding the future of work should not take

as given the technological development, adoption, and massification process, and establish geographical and time thresholds for their possible impacts. A situated perspective of the process of technological change enables us to reach more accurate forecasts and projections for the future of work.

The main problem of assuming technological change as a given process hinders the possibilities for policymaking to generic and less effective solutions. Whether the focus can be established on enabling or smoothing the change, justice as a principle allows for articulating different response levels. Since inequality could be -again- the primary outcome of the rebalance between labor and capital, creating solutions or interventions from the government will depend on the preferences or tolerance to inequality. Still, justice also serves as a medium to equilibrate prior trends uncomfortable to social preferences but assumed as given (i.e., a product of a historical process), leading to increased social cohesion. Then, policy tools could be implemented with a universal vocation (equal opportunity design) or more focalized (support specific groups adaptation), but assuming that the cost of non-action will be higher for social welfare than investing in creating opportunities for the population.

Finally, the opportunity to take up the benefits of the fourth industrial revolution appears to be conditioned by access to technologies and skill-development opportunities to gain higher efficiency in the national economy and competitive advantages at industry levels. In both cases, the government can play a relevant role in defining the process's nature, extent, and relevance by managing timing, human capital availability, and technological adoption enablers. However, since digital technologies have a more pervasive penetration in social life than computers forty years before, there is a shorter opportunity window to define to which extent the institutional setting and policy tools available can produce the desired outcomes and

which strategies could be more suited to the challenges of the current wave of technological change.

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