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Abstract

This paper surveys the literature on the effects labor market regulations on innovation, technological change and productivity growth. We consider several channels whereby labor regulations can impact innovation by increasing nonwage labor costs. In particular, the increased incentives for directed labor-saving technological change that raises capital intensity due to labor market distortions, are discussed. We also review the literature on the impact of skill biased technological change on employment and the labor share in both developed and developing countries. Evidence is provided that search costs and skill mismatch due to contractual frictions impinge on technological change and human capital accumulation. Furthermore, we elaborate the influence of labor regulations on the future of work as employers seek automation solutions or alternative work arrangements. We also explore theoretical channels and empirical evidence that the reduction in labor mobility and churning due to labor regulations inhibits technical knowledge spillovers.

Keywords: labor market regulations, innovation, technological change, productivity growth

JEL codes: J41, J50, K31, L51, 031, 033.

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1. Introduction

In this chapter we review the relationship between labor market regulations and innovation. Despite a very extensive literature on both labor market regulations and innovation, the literature on how these two areas interact is much scarcer. As pointed out by Aghion et al. (2021), most studies of labor market regulations focus on static effects (costs and benefits) rather than on dynamic effects, such as the consequences for productivity growth, technological change and innovation.

Labor market regulations can broadly be understood as formal and informal institutions which govern the contractual relationship between on the one hand labor and employees, and the on the other hand, firms and employers. Labor market regulations are a very diverse set of tools and mechanisms, and as such difficult to categorize. Regulations are often not isolated but must be understood in their institutional context which often has a mitigating effect. This means that comparing labor regulations and their effect on innovations across countries is a non-trivial task. We follow OECD (2019) that defines labor market regulations as a set of rules aiming at operationally defining employment status, extending protections beyond standard employees (for those in the grey zone between employment and self-employment) and rebalancing power asymmetries between employers/clients and employees.

Nevertheless, there are many mechanisms trough which labor regulations may influence both the speed and direction of technological innovation, and vice versa. Schumpeter (1934) identified "creative destruction" as a central mechanism for economic development, where entrepreneurs destroy old economic structures, embodying incumbent producer rents from market power, and introduce innovations that induce the loss of monopoly rents and/or the exit of existing firms. Today modern economic theory puts innovations at the centerstage of productivity growth (e.g., Acemoglu et al., 2006), but this requires reallocation of resources including labor as well as investments in R&D and human capital (e.g., Henrekson, 2020). Labor regulations influence both the ability of firms to adjust human capital and reallocate labor resources, thereby impacting the incentives to invest in R&D and human capital. At the same time, labor protection may reduce labor mobility, and significantly increase the adjustment costs for firms which may reduce innovation and technological change (Griffith and Macartney, 2016).

In principle, there are two well documented mechanism trough which labor protection may influence innovations: One is negative, and one is positive, thus making the theoretical effects ambiguous. On the negative side labor regulations increase the cost for firms and employers to adjust

labor to supply and demand conditions, which can be expected to have a detrimental effect on hiring and productivity growth (e.g. Lazear, 1990; Mortensen and Pissarides, 1994). On the other hand, increasing the firing costs for firms and increasing labor protections may create incentives for firms to invest in human capital and R&D (e.g. Nickell and Layard, 1999). Employees enjoying greater security may also have stronger incentives to invest in human capital and acquire firm-specific skills (Belot et al. 2007). In addition to these mechanisms there are further indirect effect through which labor regulation may influence innovations. If labor regulations reduce labor market churning this may for example decrease knowledge spillover between firms, which in turn may reduce innovations. As shown by Kaiser et al. (2015) and Braunerhjelm et al. (2020), regulations that impede mobility of knowledge workers can be expected to lower the rate of innovations. Further, labor regulations may differ in their impact depending on the type of innovation, i.e., process or product innovation and radical or incremental (Griffith and McCartney, 2013).

The remainder of this chapter is organized as follows. Next, section 2 provides a broad overview of types of labor regulations, the main mechanism through which employment regulations impact productivity and innovation, country comparative studies and most important previous research in this area. Section 3 goes more into details and examine the theoretical mechanism through which labor market regulation may influence the optimal capital to labor ratio. In particular, we examine how labor regulation my influence the incentives for directed technological change in the form of labor-saving innovation. Specifically, sub-section 3.1 reviews the literature on the impact of labor market regulations on directed technical change and skill wage premia as well as the labor share and job search costs. Then, sub-section 3.2 investigates automation (e.g., artificial intelligence (AI), machine learning (ML) and robotics), capital intensity and the "future of work", and how regulations may accelerate the displacement of workers performing routine tasks (both cognitive and manual). Thereafter (section 4), we examine how labor regulations influence labor market churning and mobility and how this influences knowledge spillovers. The final section 5 concludes with a brief summary of the chapter.

2. The Effect of Different Types of Labor Market Regulations on Productivity and Innovation

Labor market regulations consist of very diverse set of tools and mechanisms which governs the contractual relationships between employers and employees. These regulations are not only direct but

in many cases the regulations are also indirect, such as provisions that strengthen or weaken the bargaining power of labor unions. This makes it difficult to conduct international comparative analyses of labor regulations, albeit it has not limited ambitious attempts to compare the quality and strength of institutional differences across countries.[i] Sometimes labor regulations are also difficult to disentangle form a broader institutional context; should for example legal provisions which are part of a corporate governance system giving labor unions and employees the right to seats in the board of a firm be considered a labor regulation?[ii] In this section we take a relatively narrow approach to labor regulation and try to map types of regulations as well as identify the mechanisms through which these regulations potentially may impact innovations. Further we attempt to point towards some of the existing empirical evidence.

Typically, one can categorize regulations according to how strong protection dismissals are granted. Again, heterogeneity across countries is ample where rules differ depending on tenure of the employee, age, size of the firm and so on. In France, for example, the labor legislation becomes significantly more burdensome once a firm reaches 50 or more employees (Aghion et al, 2021). Often a distinction is made between temporary and fixed term contracts where the level of employment protection differs, often referred to as the insider/outsider system (Lindbeck and Snower, 1989). Koeniger (2005), looking at panel of OECD countries over the 1973 – 1998 period, concluded that dismissal costs have a positive relationship with R&D intensity within countries over time, but a negative relationship between countries.

The different available measures make use of both *de facto* and *de jure* labor regulations, often in combination. OECD, the World Bank, IMF among other have developed various forms of indices measuring labor regulation and the strictness of employment protection. Hence, OECD (2019) provides a detailed description of employment protection legislation across OECD, based on data 24 different areas. These range from notifications procedures and length of notice period for individual dismissals to rules on collective dismissals.[iii] The rules, taken together, determines how costly and quicky a firm can hire and fire employees. Furthermore, OECD has developed several measures of employment protection focusing on hiring and firing practices (OECD, 2020). Similarly, the World Bank collected information on labor market regulations for more than 180 countries within the Doing Business project (see World bank, 2016), however, these were not part of the Doing Business rankings reported by the World Bank.

Other studies are not that comprehensive in their country coverage but provide important insights. Botero et al. (2004) measures labor regulations in 85 countries and develop indices based on

measures of flexibility of working conditions, alternative employment contracts, and termination of contracts. The authors claim that their index reflects the "… incremental cost to the employer to deviating from a hypothetical rigid contract, in which the conditions of a job are specified, and a worker cannot be fired. This index is thus an economic measure of protection of (employed) workers, and not just a reflection of legal formalism." (Botero et al. 2004, p. 1353). They use four subindices: i) alternative employment contracts; ii) cost of increasing hours worked; iii) cost of firing workers and iv) dismissal procedures. Deakin et al. (2007) have developed an index of labor laws spanning five countries (US, UK, India, France, and Germany) covering the period 1970 - 2006 and takes 40 dimensions of labor law into account, classified on five categories: 1) alternative forms of labor contracting; 2) working time; 3) dismissals; 4) employee representation; and 5) industrial action.

Naturally the choice of indicators and aggregation method matters for the final outcome, which has been pointed out by for example by the International Labor Organization (ILO) (Aleksynska and Cazes, 2014). Nevertheless, the indicators are often correlated, though far from perfectly (e.g. Aleksynska and Cazes, 2014; and Botero et al., 2004).

Most of the empirical literature finds that stringent dismissal regulations dampen total factor productivity growth, mirroring a lower rate of innovation. Bartelsman et al. (2016) provide empirical evidence that employment protection influences different sectors asymmetrically depending on the level of risk. They argue that this has implications for technological and productivity outcomes. High risk sectors which contribute disproportionally to productivity growth are found to be smaller and have slower growth in countries with stronger employment protection (Bartelsman et al. 2016). Also, Bassanini et al. (2009) find that dismissal regulations have a negative impact on productivity growth within industries likely to be more sensitive to dismissal regulations.[iv] Consistent with these finding Murphy et al. (2017), implementing data from OECD countries to study the within country industry differences in innovation intensity, report that employment protection legislation reduces innovation for industries with higher job reallocation rates/propensity to layoff. Utilizing a reform of seniority rules in Sweden creating a natural experiment Bjuggren (2018) find that that labor market flexibility increases labor productivity. Bjuggren also concludes that this productivity effect is due to total factor productivity and not due to educational composition of employees.

Using data at a more disaggregated level to capture protection against "wrong-full discharge" at the state level in the US over the period 1970-1999, Autor et al. (2007) conclude that it influences firms' choice of production technique, increase capital deepening, and reduce total factor productivity. On the other hand, Bena et al. (2022) report that a central mechanism through which firms respond

to increasing labor market rigidities and labor dismissal costs is to increase process innovations aimed at reducing labor intensity (see also section 3).

There is also a strand of literature on how labor regulations influence investments in human capital and its subsequent impact on innovation. One argument advanced is that in countries with weak unemployment insurance or labor protection, individuals tend to underinvest in human capital (Krebs, 2003). Filippetti and Guy (2021) study how labor market regulations, in particular unemployment protection, influence the diversity of skills and knowledge and thereby potentially impact innovations. Specific regulations such as non-compete clauses/covenants have for example been suggested to be a mechanism which incentivizes firms to invest in the human capital of their employees. However, the empirical literature also suggests that this reduce knowledge spillovers, which is one very important mechanism for innovations (see section 4).

In table 1 below, we have summarized some of the previous research linking labor regulations and economic performance, either directly or indirectly, emphasizing productivity and innovation. The table is by no mean exhaustive as there is a very large body of research. Overall, the evidence is mixed: regulations can both be conducive to innovation and hamper innovation. Contingent on the specific regulation as well as the specific mechanism there are both positive and negative effects, even though the evidence seems to weigh towards the negative effects.

Table 1. Contributions to the literature on the relationship between labor market regulations, productivity and innovation

Type of regulation/measure	**Mechanism influencing innovation**	**Evidence**:	**Data:**	**Source**:
Non-compete clauses/covenants	Reduce knowledge flow/spillover, makes knowledge more excludable and reduce competition	Negative: Use/enforcement of non-compete covenant has negative effect on number of patents.	US state data 1993 until 2002. Enforcement and restrictions of non-compete covenants and patent data.	Samila and Sorenson (2011)
Priority rules/seniority rules. Based on change in Swedish labor law granting exception from seniority/priority rules for small firm.	May hinder efficient allocation of human capital by increasing the labor adjustment cost	Negative: Increasing labor market flexibility has positive effect on labor productivity.	Use an employment reform which increased labor flexibility by granting SME exception from seniority rules. Firm level data 1997-2003. Estimating effect on total factor productivity.	Bjuggren (2018)
Employment protection legislation (EPL). OECD indicator of EPL by Venn (2009).	Several theoretical mechanisms are discussed.	Mixed: Identify both positive and negative effects of EPL, depending on type of innovation (radical/incremental).	Data covers European countries and use patent data.	Griffith and Macartney (2013)

Employment protection legislation (EPL). Indicator by Blanchard and Wolfers (2000)	Theoretical explanation is positive effect on incumbent innovation but negative effect on entry.	Mixed: Dismissal costs are found to have negative impact across countries, but positive over time within countries	Data covers OECD countries 1973-1998. R&D intensity is used a dependent variable.	Koeniger (2005)
Employment protection legislation (EPL) OECD employment protection database.		Negative: Reduced innovation intensity in industries with higher layoff propensity.	Data for OECD countries 1990-1999. Labor productivity and patent data is used as dependent variables.	Murphy et al. (2017)
Rigidity of employment index (measuring difficulty of hiring and firing) World Bank, Doing Business (2003)		Negative: Stringent labor regulations are found to have a negative effect on innovation	Covers most EU countries 2002-2004. Proportion of innovative enterprises at industry level is used as dependent variable.	Barbosa and Faria (2011)
Protection against labor dismissal	Investments in cost saving production and process innovations	Negative: Labor dismissal costs drive process innovations which are labor saving	US firms with at least one patent, 1975 – 1997.	Bena et al. (2022)

Protection against unfair dismissal		Positive: Protection against unfair dismissal has positive impact on innovations	US firms and patent data.	Acharya et al. (2012)
Hiring and firing costs	Inhibit entry of innovating firms and reduce productivity growth	Negative: Lower TFP growth in countries with more labor market rigidities	Panel firm level data for OECD countries 1987-1997	Scarpetta et al. (2002)
Wrongful-discharge protection	Increased firing costs hinder labor reallocation.	Negative: Lower total factor productivity with more job protection	Data on wrongful discharges in US state courts 1970-1999.	Autor et al. (2007)
Labor adjustment costs (hiring and firing costs)	Reallocation inhibited by labor market frictions	Negative: Lower cross-term of TFP when hiring and firing costs increase	Panel firm level data covering several countries	Bartelsman, Haltiwanger and Scarpetta (2013)
Labor market flexibility	Labor reallocation towards innovative activities can boost R&D.	Negative: Reduced labor mobility hinders R&D	Micro data from the Netherlands	Kleinknecht et al. (2014),
Labor market flexibility	Job creation ease and labor mobility facilitate innovation	Mixed: Labor regulations have different effects depending on type of innovation (product/process)	Micro data on employer and employees in the Netherlands. Covers 1998-2008 period.	Wachsen and Blind (2016)

Unemployment protection/insurance	Unemployment protection can enhance job search yielding better employer-employee matches but can also lower labor diversity if it discourages re-employment	Positive: Unemployment benefits lead to better job search efforts enhancing the quality of employer-employee matches and boosting productivity.	US Survey of Income and Program Participation (SIPP) panel spanning 1985-2000.	Chetty (2008)
Labor market rigidity elimination (Unemployment protection/insurance)	More efficient labor utilizationUnemployment protection can enhance job search yielding better employer-employee matches but can also lower labor diversity if it discourages re-employment	Mixed: Faster productivity growth in countries with labor reforms increasing flexibility. Unemployment benefits lead to better job search efforts enhancing the quality of employer-employee matches and boosting productivity.	OECD cross-country panel data 1970-1998US Survey of Income and Program Participation (SIPP) panel spanning 1985-2000.	Scarpetta et al. (2000) Chetty (2008)
EPL/dismissal regulations (Labor market rigidity elimination)	More efficient labor utilization	Mixed: Industries more likely to have Stringency of temporary contract have no effect on productivity. Faster productivity growth in countries with structural labor reforms	OECD cross-country panel data 1970-1998	Bassanini et al. (2009) and Scarpetta et al. (2000)

3. Labor Regulation, Innovation and Employment

Labor regulations can generate nonwage labor costs which make it on the margin less profitable for firms to produce using labor more intensively than capital. Nonwage labor costs could increase due to labor regulations that impact hiring and firing costs as well as higher payroll taxes contributed by employers.[v] These costs induced by labor market regulations can increase the optimal capital to labor ratio as higher job creation costs can reduce labor intensity and the incentives for directed technological change can rise as labor-saving innovation becomes more prevalent.

3.2 Labor Market Regulations, Directed Technical Change, and Job Search Costs

Here we use the model from Kugler and Kugler (2009) to illustrate how nonwage labor costs from payroll tax contributions by employers disincentivize job creation. In particular, we assess the impact of payroll taxes on employment under different labor market environments. We begin by showing the effects of payroll taxes that are not linked to worker benefits in a competitive labor market.

The representative firm chooses employment, L_i, to maximize profits,

$$\pi_i = pF(L_i) - w(1+\tau)L_i,$$

taking the price, p, the wage, w, and the employment level of other firms as given, where $F(L_i)$ is the production function subject to decreasing returns and τ is the payroll tax rate firms must pay out of their wage per worker. There are M identical firms in the economy, so that aggregate employment is $L=Ml_i$, and from the first-order condition aggregate labor demand is given by,

$$pF'(L) = w(1+\tau) \qquad (1)$$

The market-clearing wage and employment levels are set to equate labor demand and supply. Labor supply depends on the wage, and on total work force, N:

$$L = [w(1+b\tau)]^{\varepsilon} N, \qquad (2)$$

where ε is the labor supply elasticity and b is the workers' valuation of the benefit from the services payroll tax contributions fund (i.e., b=1 implies a perfect link between benefits and contributions). To derive the effect of taxes on wages and employment, we first substitute (2) into (1) and take the derivative with respect to the tax rate, which yields,

$$dlnw/d\tau = - [- \varepsilon(1+\tau) / \eta + 1] / [- \varepsilon(1+\tau) / \eta + (1+\tau)],$$

where η is the labor demand elasticity. The effect of payroll taxes on employment then results from taking the derivative of (1) with respect to the tax rate and re-arranging:

$$dlnL/d\tau = \{[dlnw/d\tau] (1+\tau) + 1\}(w/L),$$

which equals zero when the tax-benefit link is perfect, b=1, when the labor supply is perfectly inelastic, ε=0, or when the labor demand is perfectly elastic, $\eta \rightarrow \infty$. This is because in all three cases taxes are fully shifted to workers as lower wages, so there are no disemployment effects. However, besides those polar cases payroll taxes will induce higher nonwage labor costs and disincentivize job creation. At the same time labor regulations that induce other higher hiring costs, besides payroll taxes such as a high minimum wage, and firing costs, in the form of employment protection legislation, also disincentivize job creation as reflected by higher incidence of unemployment and nonemployment in countries with more restrictive employment protection legislation (see for example Scarpetta, 1996). These labor regulations that make labor utilization more expensive will induce firms to prefer more capital-intensive production techniques. Over the long run, the higher cost of labor due to nonwage labor costs will induce directed technological change that is skill-biased and more complementary with capital since labor will be a relatively more expensive production factor due to regulations and as such effectively scarcer in the market with the human capital supply expanding. In general, the bias will be towards more capital-intensive production over the long-run and higher capital to labor ratio due to labor-saving innovation.

Acemoglu (1998, 2002, 2003, 2007, 2015) develops a theory of directed technological change with implications for employment, human capital accumulation and investment as well as wage premia. The analysis is based on the insights provided by Atkinson and Stiglitz (1969) of how the localized nature of innovation delivers skill-biased technological change that complements capital and increases the capital to labor ratio. While Acemoglu (2002) emphasizes increases in human capital accumulation

as a driver for directed technological change leading to skill-biased innovations, a corollary of the theory is that reductions in the effective supply of a factor, such as created by the bottlenecks due to labor regulations, can lead to innovations that are biased against that factor and result in technologies that utilize it less intensively.

Therefore, in developed countries, directed technological change driven by the increased supply of skilled labor, and exacerbated by labor regulations, has yielded increasing inequality associated with widening wage skill premia. Some of these skill-biased innovations have included information and communications (ICT) technology and other computer-related machinery. The impact of these developments on inequality trends has been documented in the case of the US in the form of a rising wage skill premium by Autor, Katz and Krueger (1998), Autor, Levy and Murmane (2003), Ciccone and Peri (2005), Autor, Katz and Kearney (2008), Acemoglu and Autor (2011), and Autor and Dorn (2013). These skill-biased technologies are complementary with capital and have resulted in both a higher capital to labor ratio and a lower labor share, that is the wage bill as a fraction of total output. The fall in the labor share has been documented in the US extensively and associated with a number of secular trends including not only labor regulations (Blanchard, 1997, and Blanchard and Giavazzi, 2003) but also rising market power (DeLoecker, et al., 2020; Autor et al., 2017 and 2018), risk sharing (Hartman-Glaser et al., 2019), globalization and offshoring (Elsby et al., 2013), social norms (Piketty, 2014), and employer monopsony power (Krueger, 2018). The secular decline in the labor share in the US documented by Kehrig and Vincent (2018) has also been observed globally as Karabarbounis and Neiman (2013) have shown. Furthermore, there has been a recent trend, documented by Katz and Krueger (2019), in US labor markets towards employers seeking alternative flexible work arrangements with gig-employment and other modalities that avoid the contractual rigidities and adjustment costs induced by labor market regulations.

In developing countries, skill-biased technological change induces productivity gaps due to human capital scarcity making it unfeasible to deploy appropriately technologies designed in industrialized countries. This is because due to directed technological change new production techniques are labor saving and induce capital intensive utilization. The productivity differences due to deploying capital and skill intensive techniques in labor abundant countries have been documented by Acemoglu and Zilibotti (2001). Indeed, workers in developing countries are impacted with lower labor productivity due to the directed technological change partially induced by labor regulations in

industrialized countries. When there is offshoring Acemoglu, Gancia and Zilibotti (2005) show that skill wage premia rise initially as offshoring induces skill-biased technical change because it rises the relative price of skill intensive products. It then generates technical change favoring unskilled workers as it expands the market size for technologies complementing unskilled labor. After enough expansion of such offshoring, it propels unskilled biased technological change, implying that the skill wage premia fall. In this case, offshoring enhances the welfare of workers in the developing regions but has an ambiguous effect on unskilled workers in the industrialized region. In further open-economy considerations of the directed technological change process, Thoenig and Verdier (2003) show that as globalization generates a rising threat of technological leapfrogging or imitation, firms respond to that challenge by biasing the direction of their innovations towards skilled labor intensive technologies. They illustrate how the dynamics of defensive skill biased innovations create rising wage gaps inequalities in both developing and industrialized regions.

Finally, Restrepo (2015) shows that when unskilled workers are abundant, skill mismatch lowers the job-finding rate of both skilled and unskilled workers. This is due both to a thick-market externality and to a complementarity effect. This means that when skill mismatch is exacerbated by labor regulations introducing contractual frictions, the incentives for upgrading skills are reduced. Firms therefore create fewer stepping-stone jobs and the reallocation of labor towards innovation activities is hampered (see Caballero and Hammour, 1996). Due to the job creation externality and the complementarity effect, the ability of a worker to find a job depends on their human capital as well as the skill mismatch induced by labor regulations. Search frictions due to hiring and firing costs decrease job opportunities for skilled workers, needed intensively in R&D activities, and dampens the reallocation and skill upgrading of unskilled workers. A corollary, and Restrepo shows evidence of this, is that recessions can induce protracted unemployment spells and more capital-intensive production. Due to their lack of required skills, unemployment spells for displaced unskilled workers are more costly than in the canonical search model of Mortensen and Pissarides (1994), as shown empirically by Davis and von Wachter (2011). Mortensen and Pissarides (1994) model unemployment in a search theoretical framework in which reallocation and technological change decrease as skill mismatch worsens due to contractual frictions, that can be due to hiring and firing costs introduced by labor regulations. The labor market search literature implies that as labor regulations can increase search costs, they can reduce labor utilization and impede innovation for technological progress and productivity growth.

Generally, labor regulations that increase nonwage labor costs can induce directed technological change biased toward production with a higher capital to labor ratio and a lower labor share. The rising adjustment costs, and other frictional costs, of labor have only been part of the story of directed technological change as human capital accumulation has led to skill abundance. Thus, the incentives have moved in the direction of both labor saving and skill biased technological change and since skills are complementary with capital, this has led to more capital-intensive production with a higher capital-labor ratio and a lower labor share. As part of this process, in the US, and other industrialized countries, there has been a rise in the wage skill premia in recent decades. In developing countries, wage gaps have partially closed in response to recent waves of globalization but labor productivity continues to lag substantially compared to industrialized countries partly due to inappropriate technology and human capital scarcity (Stewart, 1977).

3.1 Labor Regulations, Automation and the Future of Work

Labor regulation can induce automation impacting capital intensity through robot-adoption, artificial intelligence (AI) technologies and machine learning (ML) utilization, and thus the future of work. Regulation-generated (e.g., firing costs, hiring costs, payroll taxes or minimum wage) nonwage labor costs can accelerate the displacement of workers performing routine tasks (both cognitive and manual) amenable to AI, ML or robotic performance (Acemoglu and Restrepo, 2018b and 2019a; Autor and Solomons, 2018; Brynjolfsson et al., 2018; and Caselli and Manning, 2019). The evidence points towards the recent emergence of alternative work arrangements seeking contractual flexibility to avoid adjustment costs created by labor market regulations (Katz and Krueger, 2019). Another way to avoid such costs is outright automation. The emergence of this possibility has yielded a voluminous literature on the future of work prospects in view of technological developments in robot process automation, AI and ML.

In principle, automation could also complement labor through a boost in productivity and liberating time for activities in which humans have comparative advantage such as tasks intensive in creativity, analytical capacity or empathy. Automation is modeled as the successive ability of new technologies to perform tasks previously performed only by humans (Acemoglu and Restrepo, 20181, 2018b, 2018c, 2019a). Using this framework, Acemoglu and Restrepo (2020b and 2020c) find displacement of US workers by robots, and Acemoglu, Lelarge and Restrepo (2018) find a similar effect for French workers. Dekle (2020) finds limited evidence of displacement of Japanese workers

by robots and instead a positive general equilibrium macroeconomic effect on labor demand. At the same time, Graetz and Michaels (2018), based in a panel study of 17 countries, find a positive effect of robots on labor demand.

Other factors can accelerate automation. For example, ageing like labor regulations can exacerbate labor scarcity and be a catalyst for automation. Acemoglu and Restrepo (2017) show how automation mitigates secular stagnation and boosts economic growth after the demographic transition, when aging of the workforce becomes an issue. Acemoglu and Restrepo (2022) also find that in industries more amenable to automation and more intensive in utilization of middle-aged workers, robot adoption has been more intensive. Furthermore, their model also implies that the productivity effects of aging are ambiguous when technology responds to demographic change but that productivity will increase and the labor share will fall relatively in industries that are most amenable to automation, and this is indeed the pattern revealed by the evidence.

In the context of the US labor market, Acemoglu et al. (2022) find AI is currently substituting for humans in a subset of tasks but it is not yet having detectable aggregate labor market consequences. They examine how AI-related job postings impact non-AI related job postings and wages. Acemoglu and Restrepo (2019b and 2020a) emphasize that government policies and labor market regulations may impact not just the speed of automation (and thus whether there is excessive automation), but what types of technologies will receive more investments. Indeed, policy can be a driver of whether AI is designed and deployed to enhance human welfare. Relatedly, Zhang (2019) shows that a robot tax might be desirable to get the right level of automation intensity. That is the case in the absence of labor market regulations that distort the equilibrium away from the first best level of employment. In the presence of distortionary labor market regulations, it may be desirable to eliminate those regulations generating excessive nonwage labor costs that create incentives for automation before imposing a robot tax. Agrawal et al. (2018) forecast that AI and ML will change the landscape of labor markets and the future of work: This suggests that humans are likely to be displaced away from routine tasks both in cognitive and noncognitive areas leaving more scope for creative pursuits but possibly lower employment overall during the transition.

4. Labor Market Regulations, Turnover and Innovation

There is a rich literature examining inefficient matching, misallocation of resources, insider-outsider phenomenon and productivity effects that relate to how labor market regulations (see section 2)

adversely affect the functioning of the economy. However, attempts to pin down effects on innovation, using explicit innovation output variables, have been considerably less frequent. In this section we survey how labor market flexibility influences knowledge diffusion, innovation and growth, embarking from the endogenous growth literature.

4.1 The Theoretical Context

As stressed in the endogenous growth literature, knowledge spillovers is the mechanism that fuses economic development and promotes growth (Romer, 1990; Aghion and Howitt, 1992). More precisely, the accumulation, upgrading and diffusion of knowledge generates innovation that extends consumer choice and makes production processes more efficient which subsequently materializes in higher productivity and growth. Moreover, being at least partially excludable and non-rivalrous, knowledge is not exposed to the same forces of diminishing returns as other factors of production.

Even though the endogenous growth models convincingly show that investment in knowledge by individuals and firms is key in accomplishing higher growth, the diffusion of knowledge is basically exogenous, i.e., it just is assumed to take place. Thus, whereas the neoclassical models were exempt of knowledge investments and innovations, contemporary growth models tend to neglect how knowledge is diffused and transformed into societally useful innovations. Still, diffusion is the critical ingredient in the growth process to generate endogenous productivity improvements sustainable in the long-run.

An attempt to remedy that deficiency was presented in the so called Knowledge Spillover Theory of Entrepreneurship (Acs et al., 2009). The main feature of the model was that entrepreneurs, even though not investing in knowledge such as R&D, picked up findings and know-how from incumbents through various channels which then combined with heterogenous entrepreneurial abilities resulted in innovations. Hence, entrepreneurs became the conduit of knowledge spillovers. At the same time the authors stressed that also other mechanisms may prompt knowledge spillovers.

Spillovers associated with knowledge embodied in labor is one obvious knowledge diffusion candidate . More precisely, if workers move between different firms and employers, they become transmitters of the knowledge that they have acquired through their previous education and work experience, which may be valued or exploited differently in a novel environment. Such spillovers could be inhibited due to limited churning of workers, induced by labor regulations distorting the

reallocation of labor, both within and across sectors and regions. This would prevent the cross-fertilization of ideas to take place, negatively affecting innovations.

Bastgen and Holzner (2017), using an equilibrium simulation model, show that the introduction of employment protection legislation tends to generate misallocation of labour that hamper growth. However, innovations increase to counteract the lower productivity stemming from such misallocations. Still, the former effect dominates and growth is consequently affected negatively. Another outcome of the analysis is that countries with an established potential to innovate are less harmed by labour market regulations.

At the firm level, mobility may also be restrained by informal or contractually imposed conditions, i.e. non-compete clauses that have been used increasingly in the last decade. The motivation is often to guard against the loss of proprietary knowledge (Fosfuri and Rønde, 2004; Franco and Mitchell, 2008; Marx et al., 2009; Samila and Sorenson, 2011). These measures appear to have an ambiguous effect on firm innovation and fall outside the scope of the present analysis. Neither will we dwell into the specific type of regulations that may hinder labor mobility, rather we seek to provide insights regarding the relationship between labor mobility and innovation in this section. We consider three levels – the more aggregated/regional level, the industry level, and the firm level – where focus will be on the latter level.

4.2 Labor Market Turnover and Innovations: Empirical Findings at the Aggregate Level

On a more aggregate level of analysis, the geographical dimension of labour mobility has been addressed in the previous literature, providing empirical evidence that knowledge spillovers diminish with distance. Knowledge flows thus tend to be geographically localised and decay relatively rapidly (Jaffe et al., 1992; Audretsch and Feldman, 1996; Almeida and Kogut, 1999; Agrawal and Cockburn, 2003; Thompson and Fox-Kean, 2005). Studies of successful clusters and agglomerations indicate that local job changes and close interactions between employees of different firms are some of the more decisive factors in the success of such clusters (Saxenian, 1994; Fallick et al., 2006). The dominant predicament is that dense areas characterised by mobility are conducive to innovation and productivity (Kim and Marschke, 2005; Thompson and Fox-Kean, 2005). Based on Swedish local labor markets, Braunerhjelm et al. (2020) found that intra-regional mobility exerted a stronger impact than interregional mobility on firm-level innovations. Some studies, however, point in the opposite

direction. For instance, Essletzbichler and Rigby (2005) argue that inter-regional movement is more important than intra-regional mobility due to the homogeneity of human capital within regions.

The importance of knowledge spillovers to reinforce and rejuvenate technological trajectories and innovation at the industry level has also rendered considerable interest in previous research (Scherer 1983; Hu and Jaffe, 2003; Park et al., 2005; Duguet et al., 2005; Kaiser et al., 2006; Liu et al.,2013). New ideas are also likely to be materialised (or rejected) and turned into patent applications more swiftly in firms that belong to industries having an innovative culture and conceivably higher absorption capacity for innovative initiatives. It is a well-established fact that patenting activities are concentrated in relatively few industries which can be expected to be most impacted by labor mobility (Ejermo and Jung, 2014). In the literature on Jacobian (inter-industry) and Marshallian (intra-industry) externalities, the transmission of knowledge across and within industries are also extensively discussed (Rosenthal and Strange, 2003), particularly productivity and agglomeration effects. Empirically, regulatory impediments that hinder mobility have convincingly been shown to hamper innovation at the industry level (Scarpetta and Tressel, 2004; Breschi and Lissoni, 2005; 2009).

4.3 Labor Market Turnover and Innovations: Empirical Findings at the Firm Level

Although most previous studies suggest that labor mobility has a positive effect on firm level innovation, the results remain somewhat inconclusive (Agrawal et al., 2006). A few studies even find a negative relationship between innovation and the mobility of highly qualified labor, e.g., Balsvik (2011) and Parrotta and Pozzoli (2012). Zhou et al. (2009) report that high turnover of labor may lead to excessive costs due to increased internal training and administrative expenditures as well as a weaker firm-specific 'internal memory.' These studies however seem to represent a small fraction of the total analyses conducted.

Studies on the inter-firm mobility of engineers in Silicon Valley have demonstrated that movers frequently are major patent holders, i.e., they can be expected to engage in innovative activities, and that mobility is a crucial part of firm learning processes (Almeida and Kogut, 1999). Oettl and Agrawal (2008) claim that knowledge diffusion related to labor mobility also involves firms that lose workers due to improved and extended (knowledge) networks. That workers continue their contacts with the old firm seems reasonable, at least in the short to medium term, and particularly if job switches occur in the same region (Song et al., 2003; Rosenkopf and Almeida, 2003; Agrawal et al., 2006; Corredoira

and Rosenkopf. 2010). Others claim that social relationships tend to endure over many years, even as people move (Crane, 1969; Oettl and Agrawal, 2008).

A few recent empirical contributions in the literature looks specifically at how innovation performance is impacted by labor mobility, using time series data. Most rely on patents or patent applications to capture innovation. At the same time, it should be stressed that measuring innovation is an intricate task, where patents and patent application is but one incomplete measure. Implementing a standard patent production function on a Danish matched employer-employee dataset pooled with patent data, Kaiser et al. (2015) find that both firms receiving knowledge workers from other firms and those losing knowledge workers to other firms improve their innovative performance. The authors attribute the positive outcomes to extended and improved networks accelerating the knowledge flows. However, they do not consider the regional origins of employees, nor do they control for knowledge workers coming straight from the universities or how the market structure (density) influences firm innovativeness and R&D intensity. Similarly, matching issues are not discussed, reflecting the deregulated Danish labour market

Hoisl (2007) examines how labour mobility influences patenting activities, or more precisely, inventor productivity. She uses German data for the period 1993 to 1997, combining individual data on inventors with a selected number of variables aggregated at the industry level. At the individual level, the results imply a positive association between mobility and inventor productivity, indicating a better match between employers and employees and enhanced knowledge spillovers.[vi] Hoisl also concludes that there is a simultaneous relationship, i.e., less mobility may occur when productive inventors have found good matches. The empirical analysis is based on questionnaire data where more than two-thirds of the respondents abstained from answering. The representativeness of the respondents is thus unclear and, as discussed by Hoisl (2007), may create problems with selection bias.

Braunerhjelm et al. (2020), following Kaiser et al. (2015), also use detailed micro-level data where employers and employees can be matched and labour mobility tracked over time. As in Kaiser et al., the study is limited to "knowledge workers", defined through functional occupation and level of education, argued to be particularly important for innovations. Braunerhjelm at al.'s analysis is however extended in multiple ways, offering additional insights regarding the influence of labour mobility on firm innovativeness. In contrast to Kaiser et al. (2015), university graduates are included as a separate category of knowledge workers. Braunerhjelm et al. also separate labour mobility depending on whether it is generated by intra- and inter-regional flows. Moreover, in an earlier paper

(Braunerhjelm et al., 2018), it was shown that mobility of knowledge workers was positively associated with intrapreneurship and innovation for particularly smaller incumbents.

According to Ejsing et al. (2013) university graduates appears important for firms' innovative behaviour.[vii] The alleged reason is simply that graduates from the universities should be endowed with state-of-the-art knowledge as they enter the labor market, knowledge that not necessarily pertains to more experienced employees. Newly minted PhD and MSc graduates have caught up and expanded the frontier of knowledge in their fields. Evidence has also been presented by Ejermo and Ljung (2014) that higher education is positively associated with innovation activities. Theoretically Jovanovic (2009), as well as Eeckhout and Jovanovic (2012), show, assuming that the distribution of skills is heterogeneous across agents and that agents with low skill levels prefer to use old technologies, that firms will use different vintage of technologies depending on the skill structure of their labor force. Hence, in times of rapid and extensive technological change, younger cohorts are likely to play a more important role in firms' innovative activities.

At the same time, Hobjin and Jovanovic (2001) and Acs et al. (2021) argue and provide evidence pointing to younger firms, and particularly start-ups, have more incentives to design and adopt new technologies because sunk costs associated with the deployment of new vintage technologies induce inertia for incumbents, limiting technology switching. In particular, they show that the information technology revolution, that started in 1971 with the invention of the microchip processesor, could not have happened in the absence of new innovation-intensive firms emerging. These new firms were often spin-offs of existing firms bringing workers aboard from incumbent competitors, including sometimes the entrepreneur leading the new firm. Thus, labor market regulations in the form of both hiring costs, inhibiting new firm formation and expansion, and firing cost, making it hard for workers to transition from relatively older firms to start-ups, limit the transmission of knowledge to new firms that are key to boost innovation.

Labor market institutions affecting mobility consequently seems an important variable in promoting a more dynamic and innovative business sector, and is also likely to have implications for an economy's competitive strength over time. The mechanisms put forth in the literature are better matching (Bessen and Maskin, 2009) and extended networks, implying improved and extended knowledge flows between firms (Pakes and Nitzan, 1983; Mansfield, 1985; Powell et al., 1996; Zucker et al., 1998; Song et al., 2003; Hoti et al., 2006). An alternative, or possibly co-existing, mechanism may be that regulations shift the balance between employers and trade unions, leading to higher wages

which limit resources to be invested in, for instance, R&D. Malcomson (1997) refers to this as a hold-up situation, where strong labour unions may deter future investments in innovation.

To summarise, the few previously conducted empirical studies using data with extensive coverage of firms and industries over a longer time period, suggest that labor mobility has a significantly positive effect on firms' innovative behaviour. Also, to the extent that labor regulations inhibit new firm creation and expansion, partly through labour movements from old firms to start-ups, they hinder innovative activities as new firms have more incentives to design and deploy new technologies. Thus, there seems to be a substantial risk that regulations which lead to malfunctioning labour markets and lower mobility will induce weaker knowledge flows, innovation and growth. The stronger effect of intra-regional mobility reported in Braunerhjelm et al. (2020) seems to carry important normative implications at both the firm-level (where to locate) and the more aggregated policy levels (labor market regulations, how to provide attractive innovation ecosystems, etc.). Removing obstacles, in particular facilitating intra-regional mobility, may consequently be a strategy to enhance cross-fertilization of knowledge, improve matching and intensify the diffusion of spillovers in knowledge networks thereby propelling more of innovations.

5. Summary and conclusions

In this paper we have reviewed the various theoretical mechanisms through which labor regulations may influence innovations, technological change, and productivity. We also provide an overview of the existing empirical evidence.

We consider several channels whereby labor regulations can impact innovation by increasing nonwage labor costs. First, we create a taxonomy of labor market regulations and survey evidence on how different types of labor regulations affect innovation, technological change and productivity growth. Then, we discuss the increased incentives for directed labor-saving technological change that raise capital intensity due to labor market distortions. We also review the literature on the impact of skill biased technological change on both developed and developing countries on employment and the labor share. Also, we review the evidence that search costs and skill mismatches due to contractual frictions impinge on technological change and human capital accumulation. Furthermore, we elaborate the influence of labor regulations on the future of work as employers seek automation solutions, through robots, AI and ML, or alternative work arrangements. We also explore theoretical

channels and empirical evidence that the reduction in labor mobility and churning due to labor regulations inhibits knowledge spillovers, including to innovative start-ups.

The empirical evidence is somewhat mixed and sometimes the external validity is limited. The existing cross-country studies rely on various forms of aggregate measures of the stringency of labor regulations (for example hiring and firing regulations), where variables are based on composite indices. Still, the weight of the evidence seems to suggest that regulations which reduce labor adjustment and mobility have had a negative impact on productivity and innovation. With one notable exception which is that labor regulations can induce directed technological change and innovations which are labor saving.

Finally, we addressed how the mobility of labor impacts innovation, focusing at the firm level, taking into account firms receiving as well as losing knowledge workers. Overall, there seems to be robust support for a positive effect of labor mobility on firms' innovativeness. It tends to be firms receiving knowledge workers that that primarily benefit from labor mobility, but also firms that lose knowledge workers. The latter result is attributed to network effects. Furthermore, firms that have previously been engaged in innovation, and where incoming employees have previous experience in innovative firms, are associated with stronger effects from labor mobility. In addition, effects were stronger when labor moves within – rather than across – regional borders, which has implications at both the firm and policy levels related to the location of production clusters and supply chains.

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Endnotes

[i] We recognize the importance of labor unions and coverage of collective bargaining, however it's beyond the scope of this chapter to dwell in detail on the links between labor unions, labor regulations and innovations.
[ii] For a discussion, see e.g., Roe (2003).
[iii] The 24 areas are: 1) Notification procedures in the case of individual dismissal of a worker with regular contract; 2) delayed involvement before notice can start; 3) length of notice period at different tenure durations; 4) severance pay at different tenure durations; 5) Definition of unfair dismissal; 6) length of trial period; 7) compensation following unfair dismissal; 8) reinstatement option for employee following unfair dismissal; 9) maximum time period after dismissal up to which an unfair dismissal claim can be made; 10) valid cases for use of standard fixed term contracts (FTC); 11) maximum number of successive standard FTC; 12) maximum cumulated duration of successive standard FTC; 13) types of work for which temporary work agency (TWA); 14) Are there restrictions on the number of renewals and/or prolongations of TWA assignments?; 15) maximum cumulated duration of TWA assignments; 16) does the set-up of TWA require authorization or reporting of obligations? 17) do regulations ensure equal treatment of regular workers and agency workers at the use firm?; 18) definition of collective dismissal; 19) additional notification requirements on cases of collective dismissal; 20) additional delays involved in cases of collective dismissal; 21) other special costs to employers in case of collective dismissal; 22) the worker alone has the burden of proof when filing a complaint for unfair dismissal; 23) ex-ante validation of the dismissal limiting the scope of unfair dismissal complaints; 24) pre-termination resolution mechanisms granting unemployment benefits. (OECD, 2019)
[iv] Ity is noteworthy that no such effect is found for temporary employment contracts (Bassanini et al. 2009).
[v] Another regulation that could induce distortions through a wedge between the marginal product of labor and the wage is the minimum wage which raises labor costs when it is binding.
[vi] For an early analysis of mobility and matching, see Topel and Ward (1992).
[vii] More micro-oriented studies have shown how recruitment strategies may enhance learning capacities and knowledge sharing, where firms also have the opportunity to target certain universities and educations (von Hippel, 1987; Corredoira and Rosenkopf, 2010; Singh and Agrawal, 2011), thereby possibly affecting innovation.