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Technology, employment and skills: A look into job duration

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ABSTRACT

Technological change, being the adoption of new production processes or launching new products, affects employment and the relative demand for skills. In this context, we aim to study workers' job duration and the role of technology-skills complementarities in manufacturing firms. Using a Portuguese matched employer–employee longitudinal data set, we apply discrete-time duration models allowing for unobserved heterogeneity. Our results show that technological intensity reinforces the positive relationship between skills and job duration. We also find that the accumulation of specific human capital measured by time dependence plays a stronger role on reducing the hazard of job separation in more technology-intensive firms.

1. Introduction

Technological change affects employment and the relative demand for skills. While new products brought by product innovation favor new business activities, process innovation and the adoption of new technologies improves productivity and may displace workers. The job creation consequences of product innovation coupled with price and income compensation mechanisms may countervail the displacement effect of process innovation. Overall, the empirical evidence points to a positive relationship between innovation and employment (Vivarelli, 2014). However, even if innovation promotes job creation, it has two interrelated consequences for the labor market. One is the possible rise of technological unemployment. Workers displaced by technological change cannot find demand for their skills. They will probably fall into long-term unemployment or a sequence of short-term low-pay jobs with periods of unemployment in between. The other related consequence is the change in the relative demand for skills. Innovation fosters the complementarities between technology and skills, favoring the employment and wages of the high-skilled workers (Acemoglu, 2002; Doms et al., 1997).

Griliches (1969) proposed that capital (including technology) and skills are complements, in that capital increases the productivity of skilled workers relatively more than it does to unskilled workers. Under the hypothesis of technology-skill complementarity, we expect specific human capital to be valued more in more technology-intensive firms, inducing smaller hazards of job separation. Lillard and Tan (1986) found that more technology demands more specific human capital, mostly in the form of on-the-job training. Given that the hazard of job separation decreases with tenure as workers accumulate specific human capital (Farber, 1994), we expect a higher reduction in the hazard of separation with tenure in high-tech firms when compared with less technology-intensive firms. General human capital, in the form of formal education, also plays a role in determining separation rates. More-educated workers are more skilled and so, if technology and skills are complementary, we expect the hazard of job separation to be lower in more technological intensive firms.

The main question is how the use of different technologies is reflected in the way human resources are managed, namely the retention of workers, originating identifiable patterns of job duration along technology intensity and skill dimensions. With the objective of identifying these patterns, we apply different specifications of discrete-time proportional hazards models with unobserved heterogeneity to high-, medium-, and low-tech firms. We use *Quadros de Pessoal*, a longitudinal matched employer–employee data set covering all Portuguese private firms (mandatory survey collected by the Ministry of Labor). It includes detailed information on workers and firms, and allows for the mapping of workers' job-to-job flows. Our results show that more-skilled workers have lower hazards of separation and that this premium on the hazard is increasing with technology intensity. In addition, the estimated baseline hazards suggest that the accumulation of specific human capital plays a stronger role in reducing the hazard of job separation in more technological firms.

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Technological change raises concerns about the likely increase of technological unemployment and segmentation of the labor market. Our results concerning job duration are particularly relevant in a context where innovation displaces low-skilled workers, increasing their probability of becoming unemployed or of being offered short-term employment contracts. Decision-makers face the dilemma between designing innovation policies directed mainly at high-tech firms, and labor market (and education and training) policies that reduce the downside of skill-biased technological change (SBTC). The dilemma is exacerbated by the lack of flexibility associated with strong labor market segmentation prevailing in some countries. The unprotected segment comprises mainly young or low-skilled workers subject to high separation rates and with fewer opportunities for human capital accumulation.[1]

In countries facing this dilemma, namely Portugal, labor market flexibility is considered to promote the efficient formation of matches between firms and workers. From this perspective, flexibility should spur innovation by providing lower adjustment costs upon technological change, and incentives to human capital accumulation. However, an argument can be made that flexibility benefits the less-innovative firms that employ low-skilled workers, pay lower wages, do not invest in training and present higher turnovers rates. From this perspective, flexibility can be detrimental to innovation in technology-intensive firms (Kleinknecht, 1998). Shorter job durations lower firms' incentives to invest in new technologies and distort innovation decisions (Acemoglu, 1997a). If labor market deregulation fosters the use of practices such as short-term contracts and low levels of training, with the associated low levels of human capital accumulation, innovation will halt (Michie and Sheehan, 2003). In addition, the relationship between labor market flexibility and innovation hinges on the prevalent industrial relations regimes and specific characteristics of each industry (Bassanini and Ernst, 2007).

Several empirical studies find that worker and firm characteristics influence job duration.[2] Research efforts on the implications of technology on employment duration have not been as profound, though some contributions to related issues can be found throughout the literature. A stream of research has focused on how technology and technological progress influences the retirement decision of workers. For example, Bartel and Sicherman (1993) find that high levels of "permanent" technological change lead to later retirements if there is a positive relationship between training and technological change. If, however, there is a technological shock, older workers will retire earlier. Friedberg (2003) finds that computer use leads to later retirement, especially for workers in their late fifties. Ahituv and Zeira (2010) propose two different effects of technical progress on early retirement: an erosion effect where older workers invest less in learning new technologies, and a wage effect where progress raises aggregate wages, delaying retirement. They find that, in aggregate, technical change leads to unemployment and early retirement.

To our knowledge, studies concerning the relationship between technology and job duration are much scarcer. For example, using the semi-parametric Cox hazard model, Boockmann and Steffes (2010) analyze the determinants of job durations in Germany. They find that firm-level investment on information and communication technologies is negatively correlated with job separation rates, but the main focus of their study is on the different roles that observed worker, firm and institutional characteristics have on job separation. We propose to fill this gap by explicitly considering the skill-technology complementarity and the role of tenure across different levels of technology intensity.

We discuss the literature in the section that follows. Section 3 presents the data set and main variables used. We account for the applied methodology in Section 4, followed by the section with the estimation and discussion of the results. Section 6 concludes.

2. Technology, employment, and skills

The discussion about the relationship between technological change and employment goes back to, at least, the 19th century (Vivarelli, 2014). The economic theory concentrated its attention on the labor-saving effect of innovation (mainly process innovation) and the compensating mechanisms, namely: decrease in prices, new investments, decrease in wages, increase in incomes, and new products — product innovation (see the extensive discussion in Vivarelli, 2014). There is no consensus on the sign of the relationship, but the majority of the studies point to an increase in employment with innovation.[3]

The typical labor-saving nature of process innovation, by increasing labor productivity, has been contrasted with the compensation mechanism induced by product innovation. By creating new business opportunities, product innovation enhances labor demand. For example, Vivarelli et al. (1996), when studying Italian manufacturing, find an overall decrease in employment associated with innovation, mainly driven by process innovation. However, in industries with higher incidence of product innovation, the authors observe an increase in employment. More recently, Dachs and Peters (2014), using the Community Innovation Survey for 16 countries, find a net employment growth.

The employment-enhancing or displacing effect of innovation has been accompanied by a change in the skill composition of the labor force. The usage of new technologies generally requires more skills and education (Doms et al., 1997). Moreover, educated and skilled workers have a relative advantage in the implementation of new technologies (Bartel and Lichtenberg, 1987; Greenwood and Yorukoglu, 1997; Nelson and Phelps, 1966; Welch, 1970). The evidence of technology-skill complementarity (Griliches, 1969), which goes back to at least the beginning of the 20th century (Goldin and Katz, 1998), has led to the formulation of the skill-biased technological change (SBTC) hypothesis, where technological change is considered to favor skilled workers (Autor et al., 1998; Berman et al., 1994; Bound and Johnson, 1992).

Since the 1990s, a new phenomenon emerged: technological change still favored high-skilled workers, but the demand for middle-skilled workers decreased relative to the low-skilled (Autor et al., 2006; Goos and Manning, 2007; Spitz-Oener, 2006), giving rise to a polarized labor market. Developments in robotics, and advancements in computing power and artificial intelligence, combined with the decline in the price of computer capital, fostered the progressive substitution of workers performing routine tasks — tasks susceptible of being automated. Autor et al. (2003, 2006) propose a model to explain job polarization. Adding the (middle) skill-technology substitution (the routinization hypothesis) to the (high) skill-technology complementarity (the SBTC hypothesis), the authors propose a task approach, where high-skilled workers are assigned to abstract tasks; middle-skilled to routine tasks; and low-skilled to manual tasks. This approach provides the technology-driven explanation to the polarization phenomenon: the middle-skilled workers displaced by machines saw their employment level decrease. Goos et al. (2014) present recent evidence of job polarization for 16 European countries, both within and between industries, and develop a model to ascertain the contribution of the routinization hypothesis and offshoring to polarization. Furthermore, as technological change takes pace, new advancements in machine learning, mobile robotics and processing power will likely continue to foster the replacement of

[1] A brief account of the issue can be given by the figures on long-term unemployment, which represents around 52% of the total unemployment in the Euro area. The proportion is highest for Greece (74%), and higher than 50% for Italy (59%), Portugal (58%), Ireland (56%) and Spain (51%). (*Source*: Eurostat, Labor Force Survey, 3rd Quarter 2015).

[2] See, for example Bellmann et al. (2000), and Boockmann and Steffes (2010) for the German case; Booth et al. (1999) for the UK; Diebold et al. (1997) for the USA; and Horny et al. (2012) for the Portuguese case.

[3] See, for example, Bogliacino and Pianta (2010), Bogliacino et al. (2012), Ciriaci et al. (2016), Coad and Rao (2011), Harrison et al. (2014), Lachenmaier and Rottmann (2011), Mitra and Jha (2015), Piva and Vivarelli (2005), and Van Reenen (1997).