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Introduction

Innovation and employment: an introduction

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Abstract

The eight papers of this *ICC* Special Section address the relationships between innovation of different kinds—related to products, processes, or organizational arrangements—in their effects on job creation and job destruction at the level of both firm and whole sectors, in a wide range of countries from all continents except North America and Oceania. The evidence suggests that product innovation as such does not lead to job destruction but possibly to a polarization of jobs. The effects of process innovation are more controversial. At a purely firm level, a significant negative effect on employment is often absent. However, this does not rule out the possibility of industry-wide labor shedding outcomes. Finally, the evidence so far suggests that a driver of employment dynamics in Western advanced economies much more powerful than the patterns of innovation has been exerted by globalization and offshoring to competition from emerging economies like China.

JEL classification: D22, J23, O31, O33

Innovation is seen by many scholars and policy makers alike as a central element in the engine of economic growth. But it is also feared by many to be a cause of job losses. Again, in the wake of what might turn out to be a Fourth Industrial Revolution—the age of digitalization and "intelligent automation"—concerns are voiced that robots will replace human beings, or at least a large chunk of the labor force with low qualifications.

In the short run, it is straightforward that innovation shakes up the existing state of affairs, be it because new goods or services replace old goods or because new techniques require fewer workers or a different kind of skills or a re-organization within the enterprise. The question is whether these adverse effects of innovation on employment are long-lasting or whether instead some compensation mechanisms kick in and restore or even increase employment, via renewed investments, higher income growth, price-reduction induced demand, and new patterns of consumption.

It is a question which dates back to the origin of Political Economy as a discipline, from the Mercantilists to Ricardo, Marx, Keynes, all the way to Chris Freeman—holding a relatively doubtful view on the automatic force of such "compensations"—, and conversely, from Say to, indeed, Schumpeter, and of course the believers in General Equilibrium—with an optimistic faith in the self-adjusting virtues of the markets.

The issue, as discussed at much greater length in Calvino and Virgillito (2018), concerns multiple but inter-related levels of analysis. First, it concerns firms, namely, whether the introduction of innovation of different types—related to products, processes, or organizational arrangements—creates or destroys jobs, and if so, which kind of jobs. Second, it regards whole sectors in that employment changes in one firm might correlate, to different degrees, with changes of opposite sign in other competing ones.

Table 1. Characteristics of the eight studies

Study	Data	Variation	Topics
Breemersch, Damijan, and Konings	19 EU countries, two-digit industries, primary, secondary, and tertiary	Panel 1995–2010	Effects of R&D, ICT, globalization, import competition with China, and labor market regulations on employment and high-paid and low-paid employment polarization
Dosi and Yu	China Enterprises Manufacturing	Panel 1998–2007	Effects of productivity, world income, product innovation, patents, and relative unit labor cost on employment growth in the short run and in the long run
Hou *et al.*	Three EU countries manufacturing + services China Manufacturing Enterprises	Cross-sections 2002–2004 Panel 1999–2006	Harrison *et al.* (2014) model. Effects of product innovation, process innovation, and technological change on employment
Mairesse and Wu	China Enterprises Manufacturing	Panel 1999–2006	Generalization of the Harrison *et al.* (2014) model. Effects of domestic sales and exports of old and new products, growth in average wage, fixed assets, frontier and proximity to the frontier
Crespi, Tacsir, and Pereira	Chile Uruguay Costa Rica Argentina Enterprises Manufacturing	Panels 1995–2007 1998–2009 Cross-sections 2006–2007 2010–2012	Harrison *et al.* (2014) model. Effects of product innovation, process innovation and technological change on employment in general and skilled employment in particular
Cirera and Sabetti	53 developing countries Enterprises Manufacturing + services	Cross-sections 2013–2015	Harrison *et al.* (2014) model. Effects of product, process and organizational innovation, automation, degree of novelty, and technological change on employment
Calvino	Spain Enterprises Manufacturing	Panel 2004–2012	Effects of product and process innovation on the distribution of employment—quantile analysis
Barbieri, Piva, and Vivarelli	Italy Innovative enterprises Manufacturing	Panel 1998–2010	Effects of two types of innovation expenditure (R&D and investment for innovation) on employment by level of technology and firm size

However, third, innovations might be job-destroying in one sector and job-creating in other ones. This is a genuine general *disequilibrium* issue, which shall not be dealt with in the following (more on the point in Freeman *et al.*, 1982; Dosi, 1984; Freeman and Soete, 1994; Pianta, 2005; Vivarelli, 2014; Calvino and Virgillito, 2018).

The papers in this Special Section cover a wide range of countries from all continents except North America and Oceania. Six studies use enterprise data and two are based on one- or two-digit industry data. For most studies we have panel data, three of them have to work partly or entirely with cross-sectional data (see Table 1).

Among the papers based on micro-data, four (Cirera and Sabetti, 2019; Crespi *et al.*, 2019; Hou *et al.*, 2019; Mairesse and Wu, 2019) use the same modeling approach, proposed by Harrison *et al.* (2014). The model and its econometrics are sketched in Crespi *et al.* (2019). The essential idea behind the model is that there are two kinds of products—products that existed in the previous period and products new in this period. There is a labor demand equation for each type of product. As a result, employment growth can be decomposed into the employment derived from the growth in demand for the old products and the growth in demand for the new products, taking into account

the change in the efficiency of producing old products—part of which can be attributed to process innovation—and the relative efficiency of producing old and new products. It is assumed that there is no change in labor cost for the production of old products, no difference in the labor cost for old and new products, and no scale effects. The compensation mechanism is twofold: on the one hand, the demand expansion may outgrow the cannibalization of old products, and on the other hand, the efficiency improvement may lead to lower prices, which in turn stimulate demand (depending on the degree of monopoly and the price elasticity of demand). Mairesse and Wu (2019) generalize the model by splitting output into four components: domestic sales of old and new products and exports of old and new products.

The four papers use the same model and are based on innovation survey data, which collect data on the proportion of sales due to new products and therefore make it possible to identify the effects of changes in the sales of new and old products. There are some differences in the choice of instruments used to handle the endogeneity of sales data in the four papers (see Hou *et al.*, 2019, for a detailed discussion). Heterogeneity along firm sizes and technology levels is allowed for by Crespi *et al.* (2019) and Mairesse and Wu (2019), along types of ownership by Mairesse and Wu (2019), and between manufacturing and services in Hou *et al.* (2019). Automated process innovation is controlled for by Cirera and Sabetti (2019), organizational innovations by Cirera and Sabetti (2019), and shift of the frontier, distance to the frontier, growth in fixed assets and in average wage by Mairesse and Wu (2019).

The four studies based on the Harrison *et al.* (2014) model come to two similar conclusions regarding the effect of innovation on employment: the expansion of sales due to new products increases employment by more than the job losses due to the cannibalization of old products, and the negative effect of process innovation is small and often insignificant. The only exception is Costa Rica. Overall, the employment-creation effect of product innovation seems to be larger in manufacturing than in services and slightly larger in high-tech than in low-tech firms. It also seems to be stronger the further away the country is from the technological frontier and larger for unskilled than for skilled labor, because of a higher efficiency in producing new products in more advanced countries and higher capability firms. As the study by Cirera and Sabetti (2019) shows, neither automated process innovations nor organizational innovations play a significant role, although there is some evidence of automation standing in the way of employment growth stemming from product innovations.

Micro-level studies in general and also the contributions which follow depend a lot on the underlying methodologies and in particular on the theories of production and markets, which the estimated models implicitly or explicitly subscribe to. So, the four works drawing upon Harrison *et al.* (2014) build on a framework based on canonical production functions, extended in their arguments, and deriving in principle demand for firms' inputs and outputs from equilibrium relations. On the virtues and drawbacks of such an approach, even the two authors of this Introduction are likely to disagree.

Come as it may, some other studies which follow build on different underlying theories of production and competition. So, the study by Barbieri *et al.* (2019) measures innovation just from the input side, without any further assumption on the determination of production coefficients and on demand. It exploits the innovation expenditure data from the innovation surveys, in particular the R&D and the investment expenditures related to innovation. The authors find that innovation expenditures are positively correlated with employment in panel data of Italian manufacturing firms, even if the relationship is relatively small in magnitude and limited to R&D. Moreover, interestingly, it only holds for large firms and firms in high-tech sectors. The study by Calvino (2019) on Spanish data confirms the positive effect on employment of product innovations, especially in the form of new goods, and the insignificant effect of various forms of process innovation. Results from quantile regressions show that the effects of product innovations are higher at the bottom and the top of the conditional employment growth distribution, i.e., for fast-growing and shrinking firms, suggesting that the cannibalization of old products is the highest around the mean of the conditional employment distribution. For process innovations in the form of new production methods or auxiliary processes, such as IT, there is a positive significant effect on employment growth at the low end of its conditional distribution.

In China, according to Hou *et al.* (2019) and Mairesse and Wu (2019), the employment growth was due not so much to product innovation as to increased production efficiency and the sheer magnitude in the growth of sales of old products. During the period 1999–2006, there was a tremendous growth of production in China, which was driven by the export market and fueled by low wages and a favorable exchange rate.

The same conclusion is reached by Dosi and Yu (2019), who take as a starting point the wide heterogeneity in production efficiency among Chinese firms (see also Yu *et al.*, 2015) and study the interplay between technical

learning and demand growth. For each two-digit manufacturing industry, the growth in employment is shown to be negatively correlated with the growth in labor productivity and positively correlated with the growth in sales or the growth in exports. Growth in sales or exports is shown to be negatively correlated with the growth in relative unit labor cost and positively with the growth in world income, with the latter driver much more powerful than the former one. The recent surge in patents does not turn out to be significant in explaining sales or export growth. At the firm level, employment growth appears to depend, on the one hand, on productivity growth, with a direct labor shedding effect, and an indirect compensation effect through increased demand via variations in competitiveness in terms of relative market shares, on the other hand. Using a replicator dynamic process model and an increasing return Verdoorn–Kaldor model (Kaldor, 1966), Dosi and Yu (2019) find that in China the share in sales due to new products is significantly related to employment growth in the short run and more modestly in the long run. Although the *relative* level of productivity (compared to the other firms in the same sector) is positively correlated with employment growth, the *own* productivity growth, interpreted as a proxy for technological change, plays out negatively on employment growth in the long run. Sectoral sales growth has a positive effect on employment growth, directly, while, in the opposite direction, it affects productivity growth through the Verdoorn–Kaldor type increasing returns.

Breemersch *et al.* (2019) is the only paper in this Special Section that is entirely based on industry data. It uses data from 19 European OECD countries from 1997 to 2010. It has therefore the advantage to focus on the within-industry indirect effects of innovation as well as other non-technological drivers of employment changes. This study, as well as Dosi and Yu (2019), tries to take on board some of the interdependences which of course cannot be taken into account in studies that are solely based on firm data. So, an innovation in one firm can be beneficial to the firm itself but at the cost of a market loss for its domestic competitors. But, it could also boost the demand for firms that produce goods complementary to the new product. A second difference between the Breemersch *et al.* (2019) paper and most of the others is that it does not rely on innovation output data—product, process, or organizational innovation—but just two input variables, namely, R&D intensity and the use of ICT capital services per hour worked. A third major difference is that Breemersch *et al.* (2019) compare the effects of innovation and those of globalization (offshoring), Chinese net import competition, and labor market regulations on the polarization of labor in low-paid and high-paid jobs to the detriment of middle paying jobs, besides the effects on total employment. ICT adoption seems to account for around one third of high-paid within industry employment polarization in manufacturing, mostly in Western European countries, while R&D intensity does not appear to correlate with labor polarization. As to the overall effect on employment, it is not ICT or R&D intensity but rather competition with net Chinese imports which explains a large part of the overall decline in employment in Europe (one-fifth in manufacturing), especially in low-polarized industries.

Admittedly, we are still well short of disentangling the full thread of job-destroying and job-creating effects of innovation, all the way from the micro to the aggregate levels. The works which follow however add to the increasing evidence that product innovation as such does not lead to job destruction but possibly to a polarization of jobs. The effects of process innovation are more controversial. At a purely firm level, not too surprisingly, a significant negative effect from process innovation on employment is often absent. Plausibly, if a firm intensively undertakes process innovations, increases its relative productivity, and lowers its unit costs, it might well "compensate" labor-shedding with job creation via increased demand. Think of an example with elasticities of unit costs to productivity, of prices to unit costs and of demand to prices all around the value of 1. The industry-level effects, however, are a different matter. In that respect, the secular trends in agriculture are a striking example wherein a long stream of process innovations has dramatically shrunk its share of employment. Indeed, the evidence so far suggests that a driver of employment dynamics in Western-advanced economies much more powerful than the patterns of innovation has been exerted by globalization and the offshoring to/competition from emerging economies like China.

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