



# Are ICT displacing workers in the short run? Evidence from seven European countries



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## ABSTRACT

This paper examines the short run labour substitution effects of using ICT at firm-level in the manufacturing and services sectors in seven European countries, during the period 2007–2010. The data come from a unique dataset provided by the ESSLait Project on Linking Microdata, which contains internationally comparable data based on the production statistics linked at firm level with the novel ICT usage indicators. We adopt a standard conditional labour demand model and control for unobservable time-invariant firm-specific effects. The results show that ICT use has a statistically insignificant labour substitution effect and this effect is robust across countries, sectors and measures of ICT use. Our findings suggest that increased use of ICT within firms does not reduce the numbers of workers they employ.

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## 1. Introduction

Adoption of information and communication technologies (ICT) by European firms and their integration in enterprise processes are widely regarded as essential for the modernisation of EU industry and for regaining competitiveness in international markets. This is reflected in policies such as the German Strategic initiative Industry 4.0, EU Digitising European Industry initiative and The European Cloud initiative, which support the uptake of ICT with a view to improve the efficiency and flexibility of production processes and quality of the final products. However, there are serious concerns among policy-makers about the possible negative effects of these technologies on employment.

In economic literature, two main effects of ICT adoption and use on employment are considered: the substitution effect and the compensation effect. On the one hand, ICT can substitute workers either directly (e.g. robots taking up tasks previously performed by

workers) or indirectly (e.g. through increased labour productivity, which leads to less labour being needed to produce a unit of output). These effects are not limited to low-skilled workers: medium and high-skilled workers are affected as well<sup>1</sup> (Autor et al., 2003; Acemoglu and Autor, 2011; Brynjolfsson and McAfee, 2011, 2014). On the other hand, under favourable conditions,<sup>2</sup> a compensation effect may result from an increase in the demand for labour due to the ICT-driven gains in efficiency (and hence lower prices) or to the ICT-enabled product innovations, both of which lead to higher demand for firms' products. Which of the two effects prevails is subject to intense debate, but is ultimately an empirical issue. Finally, ICT could affect the skill/occupation composition of employment (Falk and Biagi, 2017), though it may not have a systematic effect on overall employment (Autor et al., 2013).

Among these effects, the substitution effect is the focus of most debate as it may lead to major disruption and uncertainty in labour markets and it is conventionally believed to cause job destruction in the short term. Moreover, the jobs eventually created through

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<sup>1</sup> In fact, there is a suggestion that ICT use might lead to de-skilling of workers, irrespective of their skills levels (Beaudry et al., 2014).

<sup>2</sup> For a discussion of these conditions, see Vivarelli (2007).

the compensation effect may require different skills than those displaced by ICT. Therefore, the magnitude of the substitution effects of ICT is important for policies which aim to support the take up of these technologies. This is particularly relevant for periods of low economic growth, such as the recent economic crisis and the current fragile recovery, when the compensation effect is likely to play a limited role.

Empirical evidence on the effect of ICT at firm level is mixed and inconclusive (Chennells and Van Reenen, 2002; Vivarelli, 2014). Studies examining the effect of ICT on employment by means of accurate firm-level measures of ICT use within firms are scarce, mainly due to lack of data (Falk, 2001; Bloom et al., 2011, are exceptions). Most studies focused on ICT-related technological change, such as process and organisational innovations, report mixed, often insignificant, effects on employment, despite theoretical suggestions that they should lead to employment destruction at least in the short run (Pianta, 2005; Vivarelli, 2014). Moreover, these studies often differ in their country, time and sector coverage, with most focusing only on the manufacturing sector. This variety in the results to a certain extent reflects the ambiguous predictions of theory and the variety of methodological approaches (Vivarelli, 2014). However, when it comes to ICT, it mainly reflects the lack of accurate indicators of ICT use and internationally-comparable firm-level data.

In this paper, we address the existing gap in the empirical literature by exploiting the unique linked micro-data that relates ICT variables to indicators of firms' economic characteristics on a comparable basis across industry groups and countries. We examine the short run substitution effect of ICT use on firms' employment separately for firms in manufacturing and services sectors in seven European countries (Finland, France, the Netherlands, Norway, Sweden, Poland, and the United Kingdom) during the period 2007–2010. To identify the substitution effect of ICT, we adopt a standard conditional labour demand model and control for unobservable time-invariant firm-specific effects which may be correlated with ICT use and firm labour demand.

Our results show no indication of significant ICT-induced labour substitution effect. This result is remarkably robust across countries, sectors and measures of ICT use. Our findings lend support to the current EU policies of promoting the take up of these technologies.

The paper makes several major contributions to the literature. First, it is one of the very few studies that examine employment effect of ICT by means of highly accurate quantitative measures of ICT use within firms. On top of capturing aspects of ICT use that remain unexploited in the literature, these variables have an advantage of measuring both ICT use and ICT diffusion within and across firms, without reaching full saturation common for the swiftly developing technologies. Second, it uses a unique dataset that contains internationally-comparable firm level data over the period 2007–2010 and examines how the relationship between ICT use and employment varies across countries and sectors. To our knowledge, this is the most representative multi-country micro-data to-date. Third, the paper focuses explicitly on the substitution effect of ICT, which is highly policy relevant in the short to medium term and in periods characterised by low economic growth.

The paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the empirical specification, while Section 4 describes the data used in our paper. Section 5 discusses the results of the estimation. Section 6 offers conclusions.

## 2. Related literature

Theoretical literature on the effect of ICT on firm labour demand suggests that several drivers are at work and that the overall effect is ambiguous. First, ICT may directly substitute workers

whose tasks become automated. Second, by increasing firm productivity (as documented by a large body of literature, recently reviewed by Van Reenen et al. (2010) and Biagi (2013), ICT enable firms to produce the same level of output with fewer inputs, including less labour. These two possible effects are often referred to in the literature as the "substitution effect" of ICT. Third, ICT-driven productivity improvements may lead to price decreases and higher demand for the firms' products, which, under certain circumstances,<sup>3</sup> would induce an outward shift of the (unconditional) labour demand. This effect is often referred to in the literature as the "compensation effect".<sup>4</sup> The combined result of the substitution and compensation effects is unclear.<sup>5</sup> The empirical literature on this topic is characterised by considerable heterogeneity in terms of the aggregation level of the analysis, effects studied (total, substitution or compensation effects), technology measures, empirical methods used and country and sector coverage.

The employment effects of ICT are closely related to the employment effects of process and organisational innovations. These innovations are important drivers of productivity growth and they have negative substitution effects (at least in the short run) and positive compensation effects on labour demand (Pianta, 2005; Vivarelli, 2014). The link between ICT investment and process and organisational innovations is complex, with ICT often being an enabler of these innovations. In particular, it has been shown that organizational innovation and ICT adoption tend to complement each other in determining productivity improvements and that ICT are a driver of (product and) process innovation (Brynjolfsson et al., 2002; Brynjolfsson and Hitt, 2003; Polder et al., 2010).

From an empirical point of view, the employment impact of ICT use is difficult to estimate: due to their multifaceted and intangible nature, technological change in general, and ICT diffusion in particular, are difficult to capture in data. A major challenge is faced by cross-country studies where international comparability often comes at the expenses of the precision in ICT proxies. Michaels et al. (2014) study on the effect of ICT capital on skill demand polarisation is one of the few cross-country studies that uses precise measures of ICT. The vast majority of studies addresses the effect of ICT on employment at the macro and sector level, and, depending on the proxy used for ICT, different employment effects surface (this heterogeneity of results can be attributed in part to the fact that different economic and institutional mechanisms are not fully accounted for in the regressions<sup>6</sup>).

Firm-level analysis has significant measurement advantages for examining the effects of ICT use as it allows to eliminate many biases resulting from aggregation. However, it is often difficult to find good quality data representative of national economies, let alone multinational regions.

There are only a few studies that have explored firm-level data on ICT use (for the United States, see, for example, Brynjolfsson et al., 2002; Brynjolfsson and Hitt, 2003; Lichtenberg, 1993; for Europe see van Leeuwen, 2008; Polder et al., 2010; Bartelsman, 2014),

<sup>3</sup> See Vivarelli (2007) for discussions on the factors that may affect this effect.

<sup>4</sup> Other "compensating" effects might arise due to the fact that i) employment will be increasing in the industries creating the new capital goods (the "machines") that substitute for workers; ii) there could be positive indirect effects from ICT use and diffusion that originate in partial (i.e. industry level) and in general equilibrium (such as an increase in aggregate consumption and investment).

<sup>5</sup> In addition to these direct effects, ICT diffusion may generate indirect employment effects in firms other than those using ICT, such as their competitors (a likely negative effect due to business stealing) and suppliers (a likely positive effect, through increased demand), with potential additional general equilibrium macroeconomic effects through increased consumption and investment.

<sup>6</sup> A good example of this ambiguity is Severgnini (2009), who contrasts a set of specifications, commonly employed in studies of labor demand, and applies them to data within and across European and non-European countries. Depending on the choice of ICT variable, the effect on employment appears to be highly dispersed and rarely significant.

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