

Raising EU productivity through innovation: lessons from improved micro data*

Reinhilde Veugelers And Frederic Warzynski

1. Introduction

Economists have devoted significant attention to research and development (R&D) as drivers of economic growth, particularly since the development of endogenous growth theory, which takes into account not only that R&D generates growth but that growth provides an incentive to invest in R&D, thus establishing a virtuous cycle (see eg Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1998). R&D is seen as a key contributor to growth because it generates knowledge, leading to new or improved products through product innovation, and makes firms more efficient at producing goods through process innovation. Firm-level studies generally find evidence of strong positive productivity effects for firms that invest in R&D.

Digital technologies have proliferated in the business sector, from the provision of digital products and services online to robotised production processes, the internet of things, big data and artificial intelligence, and applications, including digital systems to manage back office tasks. Digital systems lead to improvements in accessing and using (big) data and promoting smoother connectivity and communication. Digital systems facilitate coordination of activities within firms and with suppliers and customers. Digital systems thus can be an important driver of productivity growth, particularly in combination with investments in R&D.

Because of its transformative impact on the economy and the labour market, from both a creative and a destructive angle, economists and policymakers discuss digitalisation vigorously. There have been numerous optimistic statements that digitalisation will boost growth and productivity. Yet, while digital technologies are expected to be the drivers of economic growth and the Fourth Industrial Revolution, so far there has been little hard evidence of a significant productivity boost. More than 30 years after Robert Solow's (1987) statement "*you can see the computer age everywhere but in productivity statistics*", productivity growth in advanced economies remains subdued. At the same time, many people

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fear that digital technologies can be a source of disruption, leading to a more polarised economic structure, with the benefits concentrated in a few winners, while many economies, firms and workers will be on the losing side and will drop out.

How the relationship between productivity growth, innovation and digital technology adoption plays out is particularly important for the EU. EU productivity growth has long been weak. Recent productivity growth in the EU has been lacklustre in aggregate, while convergence between EU countries has also stalled. This lacklustre productivity growth contrasts with the potential of new technologies, and particularly digital technologies, to lift productivity growth. In fact, the EU's lacklustre productivity growth is often related to its weaker innovation performance (see eg Veugelers, 2017) and particularly its performance in digital-producing and digital-using sectors (eg Van Ark, 2015). There is growing concern that EU firms in non-digital sectors lag behind in the adoption of digital technologies, especially in the services sector, especially in digital services (EIB, 2018). In digital services, the leading 'big tech' firms are typically from the USA or China. European firms are not present among either the big tech or the leading digital R&D investors that push the frontier of digital technology (EIB, 2018; Veugelers, 2018). This raises concerns in policy debates that the EU may be falling behind in the digital technology race, being trapped on the wrong side of the innovation and digital technology divide (Veugelers *et al*, 2019).

MICROPROD contributes in several ways to the discussion on EU productivity growth, innovation and digitalisation policy. MICROPROD researchers have collaborated closely with statistical institutes to obtain the most up-to-date and precise measurements of R&D efforts and the adoption of digital technologies. Having access to high-quality firm-level data, MICROPROD researchers have been able to apply state-of-the-art techniques in the production-function literature to assess the effect of technology investments on productivity and performance. Being able to combine recent unique firm-level data and state-of-the-art research methodologies, MICROPROD research provides a better overview of which firms are most likely to adopt digital technologies, and to innovate and turn these investments into productivity growth, thus delivering high quality evidence for the policy discussion.

We first give a brief overview of the findings of these MICROPROD studies, before concluding with some policy implications and areas for further research.

2. MICROPROD research on R&D, digital technologies and productivity growth

The MICROPROD project planned initially to carry out three studies, on the relationship between productivity, R&D and ICT (see sections 2.1 to 2.3). However, collaboration with statistical offices and access to high-quality survey data enabled studies to be completed on two additional topics at the frontier of this line of research (see sections 2.4 and 2.5).

2.1 *The effect of R&D on quality, productivity and welfare*

Chan *et al* (2021) investigated the effect of product and process R&D on efficiency, quality and markups. The study provided a methodology that jointly studies demand, production and costs for multi-product firms using detailed firm-product level data from Denmark. They first estimated a demand function to obtain a measure of the demand shock. They then estimated a production function and a cost function, controlling for demand shocks, to generate implied markups. The novelty of this approach was to look at different channels for welfare improvement through demand. This joint approach is important as it allows assessment not only of efficiency as a welfare gain from R&D, but also of the quality of new products and services delivered. Assessing simultaneously the impact on mark-ups is also important, not only to understand better the incentives and internal financing constraints for innovative investments, but also to assess better the distribution of value from innovation between producers and consumers. Doing this at the firm level also allows identification of any potential sources of divergence between firms.

Chan *et al's* (2021) results provide evidence that process R&D is strongly correlated with improved efficiency, as shown by lower marginal costs and higher measured productivity, while product R&D is strongly associated with higher 'quality' (product appeal) and new product introduction. The results thus provide strong evidence that welfare – both consumer surplus and producer surplus – can be enhanced through efficiency gains, and also through increases in product quality. A proper policy evaluation should take both aspects into consideration, not only efficiency gains.

2.2 *ICT, firm growth and productivity*

Smeets and Warzynski (2020) analysed the consequences of ICT investment for firm growth and productivity. They used a rich firm-level dataset providing detailed information about spending in various components of ICT (hardware, communication equipment and software) over more than a decade (2004-2015; the survey was unfortunately discontinued afterwards).

They found strong evidence that all three components of ICT spending at the firm level correlate strongly with firm growth and productivity, although the effects of each spending component differ in subtle ways. Regarding firm employment growth, software and hardware spending are the most important factors at play, with communication playing a negligible role. Looking at a simple correlation with firm productivity, hardware has the greatest impact (though not claiming any causality at this stage), followed by communication equipment and software.

Smeets and Warzynski (2020) also tried to understand better the selection process of which firms will be most likely to engage in ICT spending to reap the growth and productivity benefits. Understanding this selection process better is important for understanding better the growing polarisation in productivity and digital technology adoption between have and have-nots. The study addressed selection through a fixed-effect estimation. It found that only hardware remains strongly positively related to efficiency in the analysis. The authors also tested alternative more structural specifications that have been used in the literature. They found a similar hierarchy: hardware being a stronger contributor to production, followed by communication and software. They also built a measure of stock of ICT capital and found ICT capital to be a strong contributor to generating sales. A similar analysis was also applied using the ICT use survey that covers a longer period (1999-2021), as discussed below.

Overall, the most plausible explanation of their findings is that firm selection is important to explain the relationship between ICT and firm performance, ie the best firms invest more in ICT. They thus provide strong support for the trend towards polarisation in digital technology adoption and growth performance.

2.3 *Import competition and firm innovation: evidence from German manufacturing*

Slavtchev (2020) looked at which factors could trigger innovation investments, using German data, with a special focus on import competition, FDI and offshoring as drivers for firm

innovation decisions. An interesting dimension introduced in the analysis was to distinguish between import competition from high-income countries and from middle- and low-income countries. This distinction helps account for differences in (i) the R&D intensity and the innovation potential of the threatened products, and (ii) the type of competition faced in the markets where the innovations are introduced. The study found that import competition from high-income countries is positively associated with an increase in the number of products offered by the firms, while import competition from middle- and low-income countries only marginally does so. This result is consistent with products produced in Germany being of relatively higher quality than products made in middle- and low-income countries, with the competition from these countries consequently being less of an incentive to invest in innovation. German firms mainly compete with products made in other advanced economies, which are also more likely to be of high quality. Import competition from these countries is therefore more likely to be an incentive for investing in innovation.

2.4 AI adoption and productivity

A recent literature has discussed what is referred to as a “*new productivity paradox*”: that while artificial intelligence (AI) or machine learning has the potential to generate substantial productivity gains in the near future, as it can be seen as a general purpose technology, the data so far fails to show this potential. AI could become pervasive, can be improved over time, and can generate (‘spawn’) waves of complementary innovations. But despite this, data shows a productivity slowdown. A major reason might be the nurturing of false hopes. Maybe AI is not really a general purpose technology. A second more plausible explanation is that implementation of that technology is too early to be assessed because of implementation lags: firms need time to learn about how to best use AI and combine it with other assets. Another reason is mismeasurement of AI adoption, which raises the question of how to properly measure AI over time.

To help address the measurement of AI, Warzynski (2022) used several waves of recently released surveys on digital technology adoption to identify firms adopting AI in Denmark. Questions about AI adoption were only introduced in 2017. The paper documented an extremely rapid diffusion of AI among the sample firms in four years: from 6.62 percent of firms in 2017 to 23.89 percent in 2021. Going further, the paper found preliminary evidence of a large performance premium for those firms introducing AI. This positive premium is

mostly explained by selection, but also by improvement in productivity in the short run. Finally, the paper showed preliminary evidence of complementarity between AI and skilled (tech) workers in AI-intensive industries, suggesting that the combination of human skills and new AI technologies might be key in driving productivity growth. Altogether, these findings suggest that measurement issues, together with informational and implementation lags, could play a major role in solving the new productivity paradox for AI, although these are still preliminary findings. It also suggests again the importance of selection, with the best firms to implement AI effectively being those with strong human (tech) skills.

2.5 High-skill immigration, offshore R&D and firm dynamics

Firms can choose different ways in which to organise their R&D activities, especially in a small open economy where talent is scarce. Fan *et al* (2022) studied firms' decision to use foreign R&D inputs – immigrant researchers and imported R&D services – in addition to doing domestic R&D with local workers. They looked at the implications of the combination of these different channels for firm performance and aggregate productivity using Danish data. They showed that firms with immigrant researchers are more likely to source foreign R&D services, and using foreign R&D inputs increases R&D efficiency and firm performance. They then developed and estimated a model of firm dynamics that rationalises these patterns. Counterfactual experiments show that the two foreign inputs, immigrant researchers and foreign R&D services, play crucial yet complementary roles in R&D. They show that the benefit from foreign R&D inputs is an important motive for firms to carry out R&D. Without access to these inputs, the R&D participation rate would decrease by 60 percent and the effect of R&D on aggregate productivity would shrink by 80 percent. Hence, omitting foreign inputs would lead researchers to substantially underestimate the effect of an R&D subsidy on aggregate productivity. Moreover, as they estimate important complementarity between the two foreign inputs, policies that change the cost of hiring immigrants have a significant impact on firms' offshore R&D decisions, and vice versa. Not accounting for such interconnection underestimates the impacts of these policies on aggregate productivity by 30 percent to 50 percent. Fan *et al's* (2022) analysis suggests that shutting down access to skilled immigrant labour or creating barriers to offshoring R&D would create impediments to growth.

3. Summary of main findings, concluding policy implication remarks and avenues for further research

Investments in R&D and the adoption of digital technologies in the business sector are important drivers of productivity and growth. Yet productivity and growth remain below expectations and uneven.

Because of their transformative impact on the economy and the labour market, from both a creative and a destructive angle, innovation and digitalisation are vigorously discussed by economists and policymakers, especially in the EU, where there is a fear that the EU may be falling behind in the innovation and digital technology race, and may not be able to take up leading positions in new races. If European firms are unable to integrate new digital technologies into their innovations, they will lose out, even in those sectors where they are currently still leading.

MICROPROD research has contributed to this important policy debate for the EU first by reducing the mismeasurement issue. It has done so by working closely with statistical offices to improve access to high-quality firm-level survey data for analysis. Second, being able to use high-quality recent firm-level survey data in combination with state-of-the-art methodologies has allowed MICROPROD research to bring new findings to the debate, helping to explain the paradox, by finding clear evidence that R&D and adoption of digital technologies, when properly and recently measured at firm level, do provide positive performance benefits. These positive performance benefits should be looked at not only in terms of efficiency advantages but also in terms of higher quality new products and services being offered. This positive association is however most likely due to selection, ie the best firms are innovating and investing more in digital technologies. MICROPROD research thus provide strong support for a trend towards polarisation in digital technology adoption and growth performance, driving a gap between the have and have-nots. Further MICROPROD analysis on firm selection identified the importance of complementary high-quality labour skills and openness to international R&D skills and services, in explaining which firms are most likely to be on the right side of the digital innovation divide.

Clearly more work is needed to identify the characteristics most likely to explain which firms select into innovation and digital technology investment, and which firms can create and

capture value from these investments. These include further exploring firm characteristics in terms of firm size, firm age, firm management and governance, but also technology, market, regional and country characteristics driving the R&D, digital technology and performance relationships. Finally, further research should also look at which policy levers are most effective in improving the incentives for firms to invest in innovation and digital technology adoption, particularly for those firms at risk of falling behind.

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