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"Measuring and Accounting for Innovation in the 21st Century"

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ICT and Innovation

Michael Polder (Statistics Netherlands)
Pierre Mohnen (Maastricht University)
George van Leeuwen (Statistics Netherlands)

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For 25 years now innovation survey data have been collected in many countries of the world providing information on the occurrence of different types of innovation, the extent of innovation expenditures (which include but are not restricted to R&D), and the extent or the intensity of product innovation (and in a few countries also of process innovations). The data have been collected in a standardized way following the guidelines of the Oslo Manual. Hundreds of papers have been written investigating the determinants of innovation from firm characteristics to industry structures, the links between innovation inputs and outputs, and the effects of innovation on measures of economic performance such as productivity, profitability, employment, firm survival or trade. Although we have learned quite a bit in the course of these years about how and why innovation occurs and how it affects firm performance and country growth, many questions remain unanswered.

Another literature has examined the role of ICT on firm productivity. Capital has been split into ICT and non-ICT capital, and the productivity of each has been estimated and related to the evolution of productivity growth. A great deal of productivity growth in the last 30 years has been ascribed to ICT capital. ICT has also been related to innovation mainly via the complementarity between ICT adoption and organizational innovation and many studies have corroborated this complementarity hypothesis. What has been less explored is the extent to which product and process innovations are ICT-related - in the sense that without the ICT-revolution a lot of these innovations would not have taken place – and ICT-facilitated in the sense that ICT makes many innovations possible but also forces firms to innovate in order to remain competitive.

The aim of our paper is to explore the enabling impact of ICT on innovation and through that channel on productivity. We aim to test the complementarity between not just organizational (or more generally organizational and marketing) innovations and ICT, but also between product and process (so-called technological) innovations and ICT as they affect productivity. In other words, does the use of ICT technology enhance the returns to innovation in terms of productivity or in terms of other measures of economic performance, like profitability, exports or employment.

The data we use are sourced from different surveys at Statistics Netherlands, which are linked at the firm level. The sample includes firms in the manufacturing sector (NACE Rev. 1.2 15 to 37) as well as the services sector (NACE Rev. 1.2 50 to 93). The innovation variables are sourced from the Community Innovation Survey (CIS). We pool the data from at least four biannual innovation survey waves starting in 2002. Information on ICT usage comes from the annual (since 2002) Business ICT (E-commerce) survey. Investment in ICT (hardware) is taken from the Investment Statistics . Finally, production data (production value, factor costs, and employment) are taken from the Production Statistics. We use price information at the lowest available level from the Supply and Use tables.

The model would consist of a kind of CDM multi-equation model, where the production function is a function of ICT-capital, non-ICT capital, labor and combinations of innovation outputs and an unobserved random productivity term. The impact of innovation is allowed to be moderated by the ICT intensity of a firm. ICT-capital could be measured by accumulated ICT investment, or proxied by broadband intensity or the number of ICT specialists. This is where the enhancing effect of ICT-capital on innovation would possibly show up. This equation would be estimated by GMM along the lines of Ackerberg, Caves and Frazer (2015) or Doraszelski-Jaumandreu (2013). Given the binary nature of the innovation data, product, process and organizational innovations would be modeled as simultaneous probit equations, where the innovation indicators would be mutually dependent, as well as on R&D and ICT variables. This is where the enabling effect of ICT on the occurrence of innovation is allowed for. This set of equations would be estimated as an endogenous multivariate probit model. R&D is treated as predetermined in the innovation output equations and is supposed to affect economic performance through innovation. An effort will be made to make the model as simple as possible avoiding the curse of dimensionality when formally testing for complementarity.