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# Broadband adoption and firm productivity: Evidence from Irish manufacturing firms<sup>☆</sup>

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## ARTICLE INFO

Available online 27 November 2014

## Keywords:

Broadband adoption  
 Firm productivity  
 IV regression  
 Industry

## ABSTRACT

We estimate the effects of adopting DSL broadband on firm productivity and productivity growth allowing for differing broadband speeds. We use a two-stage least squares estimator with geographical broadband availability as an instrument to address some potential endogeneity problems in a panel of Irish manufacturing firms. While more productive firms are on average more likely to be using DSL broadband, we find no statistically significant effect of broadband adoption on firms' productivity or productivity growth.

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## 1. Introduction

Investment in information and communication technologies (ICT) has historically made a significant contribution to aggregate productivity growth (Kretschmer, 2012). Policymakers understandably seek to obtain further societal benefits from this source by encouraging investment in the latest forms of ICT. Yet it is not obvious that the benefits of past generations of technology will necessarily be repeated in future ones. Firms and governments are now contemplating sizeable investments and other forms of support for high speed 'next generation' broadband (Marcus & Elixmann, 2014). One factor behind this enthusiasm is an expectation that high speed broadband will increase the productivity of firms that use it (Howell & Grimes, 2010). But the view that adoption of basic broadband, as opposed to ICT investment generally, increased firms' productivity has surprisingly limited empirical support (discussed below). Even if one is willing to extrapolate the experience of basic broadband to its high speed successor, it is reasonable to ask whether adoption by firms of basic broadband had a direct effect on productivity or not. This paper adds to the literature on the effects of ICT by asking whether we can observe the sorts of productivity benefits seen in macro data when we focus on the micro level. More importantly, it adds to the limited base of evidence on the specific effects of broadband adoption on firms' productivity.

Empirical research in this area began with studies of the effects of ICT, particularly following identification by Solow (1987) of what came to be called the 'productivity paradox'. As the technology frontier has advanced, so has the technological focus for productivity research moved on. The current policy preoccupation is whether high-speed 'next generation' broadband services may increase productivity and increase societal welfare in various other ways, and how or

<sup>☆</sup> This work makes use of data from the Central Statistics Office (CSO). The possibility for controlled access to the confidential micro data set on the premises of the CSO is provided for in the Statistics Act 1993. The use of CSO data in this work does not imply the endorsement of the CSO in relation to the interpretation or analysis of the data. This work uses a research dataset which may not exactly reproduce statistical aggregates published by the CSO.

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whether governments should intervene to accelerate the deployment of such services (Kenny & Kenny, 2011). Nevertheless, the literature specifically trying to quantify the productivity contribution that broadband services offer to firms remains limited, perhaps due to a scarcity of firm level data linking broadband availability to adoption and total factor productivity. This is where the present paper makes a contribution. We have panel data on both firms' productivity and local supply of broadband services covering nearly the full period of broadband roll-out in Ireland. This allows us to control for unobserved heterogeneity and to address endogeneity concerns. Moreover, we are able to examine whether broadband speed matters for the effect.

At the macro level there is a substantial literature on how broadband affects GDP growth and employment (for example the surveys by Czernich, Falck, Kretschmer, & Woessmann, 2011; Holt & Jamison, 2009) or studies of ICT rather than broadband specifically (see Kretschmer, 2012 for a recent survey). Studies using aggregate data to measure the productivity effects of ICT typically estimate production functions on national- or regional-level panel data. Establishing causality is a challenge in this setting. Reverse causality is a possibility, as telecoms network operators may be more likely to make broadband available in countries that have many highly productive firms and firms that have higher productivity might be better placed to adopt broadband. In addition, important omitted variables could drive both broadband adoption and productivity at national level. For example, a stronger endowment of human capital or a greater export orientation in country's industries could have positive effects on both productivity and broadband adoption if increased human capital or exporting tend to raise demand for broadband services.

In contrast to the typically positive effects of broadband adoption at higher levels of aggregation, firm-level studies have found little evidence of productivity effects of broadband adoption per se. Evidence of positive effects appears to be limited to cross-section studies. Grimes, Ren, and Stevens (2012) report that broadband adoption has a positive effect of 7–10% on productivity in a study of over 5500 firms in New Zealand in 2006 using propensity score matching methods. Hagén, Glantz, and Nilsson (2008) in a cross-section of Swedish firms between 2001 and 2005 find a significant relationship between broadband adoption and productivity for the 2001–2002 period, but not later. They suggest that this lack of significance may be due to a small sample size in subsequent years. Bertschek, Cerquera, and Klein (2013) find no effect of broadband adoption on labour productivity using a cross section of 1000 firms in German manufacturing and services sectors. They do find positive effects on product and process innovation.

Using panel data for a large sample of firms from the Netherlands (2002–2005) and the UK (2001–2005) in the manufacturing and services sectors, van Leeuwen and Farooqui (2008) conclude that productivity improvements from adoption of broadband come through capital deepening rather than TFP. They also find that TFP is increased by electronic sales but not by electronic buying. Colombo, Croce, and Grilli (2013) examine the effect of broadband adoption on productivity in a sample of small- and medium-sized Italian manufacturing and service enterprises during the period 1998–2004. They find that broadband adoption has no significant effect on productivity by itself, but they identify some positive effects for specific types of broadband applications depending on the sector.

The effects that go beyond broadband adoption per se identified in the above papers are in line with a substantial literature that aims to measure the effects of ICT adoption and use at the firm level (surveyed in Draca, Sadun, & van Reenen, 2007). However, what matters from a policy point of view is whether there are productivity effects from broadband adoption per se. Politicians or civil servants will not be able to make the roll-out of next generation broadband conditional on firms using it for purposes which have been shown to be productivity enhancing.

The main contribution in this paper is to estimate productivity effects from broadband adoption using firm-level panel data, allowing for differing broadband speeds. We use a two-stage least squares estimator with geographical broadband availability as an instrument to address some potential endogeneity problems (similar to Bertschek et al., 2013). Our use of panel data also allows us to control for firm- and time-specific heterogeneity. Our panel includes over 8000 observations from about 2200 manufacturing firms in the Republic of Ireland from 2002 to 2009.

We find that higher productivity firms are more likely to use broadband without controlling for firm characteristics, so the concern about possible reverse causality may be valid. We find no statistically significant effect of broadband adoption on firms' productivity or productivity growth. This is true for a measure of all broadband services taken together as well as when focusing on higher-speed broadband specifically.

The remainder of this paper is structured as follows: Section 2 discusses the methodology used in the analysis. Section 3 describes the different data sets and provides descriptive statistics. In Section 4 we present our main results. Section 5 provides some robustness tests and Section 6 briefly concludes.

## 2. Methodology

In order to assess the importance of broadband (DSL) on firms' productivity (growth) we postulate that broadband is a potentially productivity-enhancing technology:

$$Y_{it} = \alpha_i + \beta_{DSL} DSL_{it} + \beta_X \mathbf{X}_{it} + \varepsilon_{it}. \quad (1)$$

$Y_{it}$  denotes firm  $i$ 's productivity or productivity growth at time  $t$ ,  $\alpha_i$  is a constant term, DSL is a dummy variable equal to one if the firm uses broadband,  $\mathbf{X}_{it}$  is a vector of control variables and  $\varepsilon_{it}$  is an i.i.d. error term.

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