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ICT services and small businesses' productivity gains: An analysis of the adoption of broadband Internet technology

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ABSTRACT

We analyse the impact of the adoption of broadband Internet technology on the productivity performance of small and medium enterprises (SMEs). We distinguish access to the broadband infrastructure from the adoption of complementary services, i.e., different types of broadband software applications. The empirical analysis considers a sample of 799 firms observed from 1998 to 2004 that are representative of the population of Italian SMEs. Our econometric estimates indicate that the impact of the adoption by SMEs of basic broadband applications is negligible (or even negative). Conversely, SMEs are found to benefit from adopting selected advanced broadband applications depending on several contingent factors: (i) their industry of operations (services vs. manufacturing); (ii) the relevance of the specific broadband software applications for SMEs' industry of operation; and (iii) the undertaking of complementary strategic and organisational changes.

1. Introduction

The economics literature has investigated the effects of information and communications technology (ICT) adoption on firm productivity at two different levels of analysis. From a macroperspective, the evidence is not univocal. Although important contributions underline the significant positive effect of ICT on productivity (e.g., Jorgenson et al., 2008), a conspicuous number of empirical studies at the industry- and country-wide levels have highlighted a very limited or even negative impact of ICT, offering support to Solow's famous productivity paradox (Solow, 1987. See also, among others, Van Ark et al., 2003; Pilat et al., 2002). Conversely, studies that address firm-level data control for firm-specific characteristics such as organisational factors, complementary skills and related strategies that are not detectable at the aggregate level, but they point more convincingly to a positive and significant effect of ICT (see Section 2.1 for more details on these studies).

Our paper belongs to the firm-level stream of literature and presents important points of interest and novelty. First, we analyse a fairly recent and extremely relevant type of ICT capital: broadband Internet technology. Although other studies have examined the economic impact of this technology, we note a fundamental distinction between access to the infrastructure (i.e., the adoption of a broadband Internet connection) and the adoption of related services (i.e., different broadband software applications). Second, we focus on a category of firms, small and medium enterprises (SMEs), that represents a significant portion of today's production systems in most advanced economies.[1] Despite the relevance of this category of firms, the diffusion of broadband Internet technology among SMEs has not received sufficient attention. Third, for reasons detailed throughout the text, we make a further distinction between SMEs that are active in service industries and those operating in manufacturing industries. Fourth, we analyse the causal relationship between the adoption of broadband

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[1] According to OECD (2005), SMEs account for more than 95% of manufacturing enterprises in advanced economies and an even higher share in many service industries. They generate approximately two-thirds of private sector employment.

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Internet technology and SME productivity, taking into consideration the possible interplay of important firm-level contingent variables and moderating factors. In particular, our investigation focuses on changes in a firm's organisation and strategy brought about by the adoption of broadband software applications as important enablers of productivity gains for SMEs. By focusing attention on the interplay between different types of small businesses and different types of broadband software applications, our paper investigates the specific conditions under which ICT helps SMEs increase their efficiency and performance.

Grounded in the extant empirical evidence about the impact of telecommunications infrastructure on economic development (e.g., Roeller and Waverman, 2001), an increasing number of macro-analyses have recently documented the crucial role of broadband communications networks in spurring economic growth (see the econometric studies based on data on OECD countries by Koutroumpis (2009) and Czernich et al. (2011) and the analysis based on US data by Crandall et al. (2007)). In this domain, broadband Internet connection is considered a particularly powerful instrument, especially for SMEs, because it offers this type of firm an efficient and permanent connectivity to the global market at a price that many SMEs could not previously afford. Furthermore, it permits the use of complementary broadband software applications that provide high value-added services. In fact, a broadband connection is simply an "enabling" technology, allowing SMEs to adopt a series of valuable complementary applications, such as advanced communications (e.g., virtual private network, VoIP and videoconferencing) and management applications (e.g., customer relationship management, supply chain management, human resource and administration management systems) that may significantly increase firms' efficiency and performance (OECD, 2003).

This study extends our understanding of the positive influence of broadband deployment on economic systems highlighted by studies that have embraced a macro-level perspective since it produces novel insights into the productivity-enhancing role of broadband technology and the underlying conditions for its efficient use by SMEs. Despite the importance of this issue, there is a dearth of empirical quantitative studies on the impact of broadband Internet technology on the productivity performance of SMEs. Grimes et al. (2012) present the first firm-level study that focuses on productivity gains sourced from upgraded Internet access. They examine the impact of adoption of different types (i.e., speeds) of Internet connectivity on a sample of New Zealand firms (not necessarily SMEs) and find that broadband connection does increase firm productivity on the order of +7% to +10%. To the best of our knowledge, the only other econometric firm-level analysis on this topic was conducted by Bertschek et al. (2012). The authors focus on the adoption of broadband Internet connection by a sample of large and small to medium-size German firms between 2001 and 2003. Their analysis highlights a positive and statistically significant impact of broadband Internet connection on a firm's innovation activity, but, at the same time, it points to a smaller and statistically weak impact on labour productivity. This latter result appears to be driven by a high level of variance in broadband adopters' productivity, with few firms boosting their efficiency after adoption and a considerable number of adopters obtaining only small productivity gains. Both of the above-mentioned studies concentrate on the impact exerted by the adoption of broadband Internet connection in isolation without considering possible intervening related factors prompted by the Internet upgrade. Conversely, our starting point is that a broadband Internet connection does not, by itself, generate productivity gains for SMEs; instead, it is the use of specific broadband software applications that may make a difference depending on the specific characteristics of the adopting SMEs. In particular, we claim that the extent of the positive effect of broadband software applications is contingent on (i) the type of application (see Forman et al. (2012) for a similar approach distinguishing basic and advanced Internet use); (ii) the specific potential that the application possesses in the industry of operations of the adopting firm; and (iii) the firm's ability to implement the complementary changes necessary to efficiently use the application.

Accordingly, we develop a series of hypotheses concerning the alleged positive effect of the use of broadband software applications on SME productivity and the firm-level contingencies that moderate this relationship. These hypotheses are then tested on a longitudinal dataset of Italian SMEs. The dataset includes information from 799 Italian SMEs operating in both manufacturing and service industries (excluding public administration, finance and insurance). The sample is stratified by industry, size class and geographical area to be representative of the population of Italian SMEs. It contains detailed primary information obtained through phone interviews to SMEs' managers on firm-specific characteristics and SMEs' adoption of a broadband Internet connection and broadband software applications over the period from 1998 to 2004. Production function is estimated using a generalised method of moments (GMM) approach (Blundell and Bond, 1998) to control for potential endogeneity between productivity and its inputs. Overall, the results of the empirical analysis reveal that broadband Internet technology may indeed have a positive effect on the productivity of small businesses. However, this positive effect is far from being automatic and depends on both the selective adoption of advanced applications suitable to an SME's operation environment and the undertaking of complementary strategic and organisational changes. These results confirm the importance of differentiating between various levels of analysis to improve our understanding of the conditions under which ICT affects SME performance.

The paper is organised as follows. Section 2 briefly describes the literature on the effect of ICT on firm performance and derives the research hypotheses. Section 3 is dedicated to a description of the data. Section 4 is devoted to the empirical methodology; we illustrate the rationale underlying our empirical strategy, the variables used (Section 4.1), the model specification (Section 4.2), the tests we perform to test our hypotheses (Section 4.3) and the econometric methodology (Section 4.4). Section 5 highlights the results of the empirical analysis, and Section 6 concludes with summarising remarks and some managerial and policy implications.