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Does upstream regulation matter when measuring the efficiency impact of information technology? Evidence across EU and US industries

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ABSTRACT

We examine the role of ICT in reducing industry level technical inefficiency, controlling for the impact of upstream regulations. We conduct industry level stochastic frontier analysis and estimate a technical inefficiency model which allows for an interaction between ICT and upstream regulation. A panel dataset from EU and US industries is used for the period 1995–2007. We find that ICT contributes significantly in reducing technical inefficiency in low technology manufacturing. In service industries this influence is strong only at low levels of regulation. Likewise, in the same sectors, anticompetitive regulation exerts an increasing effect on inefficiency. We fail to establish any significant influence of ICT on the efficiency of high technology industries. When considering alternative dimensions of regulation, most regression estimates confirm baseline results as regards the inefficiency influence of either ICT or regulation. However, the conditional impact of ICT differentiates and depends on the type of regulation examined.

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1. Introduction

The emergence of Information and Communication Technologies (ICT) is a major factor accounting for higher labor productivity growth witnessed in both the US and EU economies (Van Ark et al., 2003). Although ICT is a technology readily available in world markets, it seems that only few developed countries have managed to realize substantial benefits from its use. This partly reflects the existence of diverging competition policies across countries which, in turn, influence firms' decisions to invest in ICT. Conway et al. (2006) have argued that the incentive to invest in ICT is stronger in countries and sectors characterized by lower regulation. Similarly, policies that favor competition are considered as an important factor for the improvement of productivity (Nicoletti and Scarpetta, 2003; Aghion et al., 2009).

Most of the research conducted so far focuses on the direct effects of ICT on productivity, without considering whether its influence depends on the degree of the regulatory burden. The 2013 European Competitiveness Report (see Chapter 3) shows that both

ICT and product market regulation exert an important influence on the efficiency gap of EU countries and industries. In relation to this study, we go one step further and consider whether regulation shapes the efficiency impact of ICT, thus measuring its influence at various levels of regulation.

While most of the related studies explore the direct effects of regulation within the same sector, we focus on the influence of anti-competitive regulations in the upstream sectors of energy transport and communications on the efficiency performance of sectors which use as intermediate inputs the services produced by these network industries. Regulation in upstream industries might be particularly harmful for the efficiency of sectors which use their services as an intermediate input, as part of the expected efficiency gains might be grabbed by intermediate input providers (Bourles et al., 2013). Importantly, we analyze the efficiency impact of the various dimensions of upstream regulation related to entry barriers, public ownership and market structure.

We employ a stochastic frontier analysis across nineteen two digit industries of the EU and the US during 1995–2007. This period is of particular interest as it coincides with the advent of the digital revolution that led to a surge of investment in ICT (Table 2) and a substantial decrease of upstream regulation as shown in Fig. 1 of the Appendix.

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We show that ICT contributes significantly in reducing technical inefficiency in low technology manufacturing. In service industries this influence is strong only at low levels of regulation. Similarly, anticompetitive regulation exerts an increasing effect on inefficiency of services and low technology manufacturing. In high technology industries, we fail to establish any significant impact of ICT. When considering specific dimensions of regulation, we verify initial estimates as regards the inefficiency influence of either ICT or regulation. Nevertheless, the conditional impact of ICT varies and depends on the type of regulation examined. We show that the efficiency gains are substantial after an increase in ICT investment or a decrease in the level of regulation.

The rest of this paper is organized as follows. Section 2 introduces the theoretical framework and summarizes the findings of the relevant literature. Section 3 discusses the econometric specification of the paper. In Section 4 the data are described and some descriptive statistics are provided. Section 5 presents and discusses the empirical result. Finally, Section 6 concludes.

2. Theoretical framework and related literature

2.1. Theoretical framework

Economic theory predicts that an increase in competition results in higher efficiency. In particular, competition increases efficiency by reallocating market shares to most efficient firms, by forcing exit of less productive ones and by allowing more innovative businesses to enter the market (Melitz, 2003). Aghion and Schankerman (2004) provide a theoretical framework showing that competition enhancing policies improve productivity through the exit of less efficient firms and entry of new more efficient ones and through the promotion cost reducing technologies.¹

In relation to the upstream regulation in service industries, Bourles et al. (2013) argue that this type of regulation increases the cost of production which is transferred to downstream industries through the purchase of intermediate inputs. This constitutes a barrier to entry as access to such inputs is at higher prices compared to a market without frictions. Similarly, imperfect competition in upstream sectors makes search for intermediate input providers time consuming and costly. Such costs provide market power to input suppliers, create a barrier to entry in downstream sectors and finally reduce the number of firms. They also distort incentives of incumbent firms to improve efficiency through properly allocating their factor inputs.

In relation to ICT diffusion, strict regulations that protect rents in upstream industries may reduce incentives to search for and implement efficiency improvements in other industries, as part of the expected downstream rents from adopting best practice techniques will be grabbed by intermediate input providers (Bourles et al., 2013). Conversely, stronger competition in upstream industries increases incentives to improve technology of downstream firms as they will be the ones who will appropriate the benefits of their

¹ Disney et al. (2003) and Syverson (2004) showed that competition reduces productivity dispersion by reallocating shares to most productive firms. Recent neo-Schumpeterian studies argue that, as competition increases, incumbent firms engage in higher innovation in order to preserve their market shares. Aghion et al. (2005) show the existence of an inverse-U relationship between competition and innovation. Essentially, at low stages of competition, an increase in competition in the market will increase innovation, since the escape competition effect dominates the Schumpeterian effect and pushes firms in an industry to innovate in order to avoid losing market shares. At higher levels of competition, the Schumpeterian effect is more likely to dominate, so that an increase of competition will result in lower innovation activity. Similarly, the escape competition effect is likely to dominate in industries where a large proportion of firms are close to the productivity frontier. On the other hand, in industries which are far away from the technology frontier, the Schumpeterian effect is likely to dominate and deter any innovation activity.

own investments.² In a similar way, we expect that higher regulation in upstream industries might result in a lower than optimal utilization of the existing resources. Firms and industries facing a higher degree of regulatory burden are not sufficiently motivated to use their ICT infrastructure efficiently, as part of the expected gains will not be reaped internally.

Special features of ICT that affect directly economic efficiency include trade of goods and services at low cost which lead to gains through scale economies and realization of comparative advantage (Harris, 1995). Efficient management of knowledge, timely and widespread transfer of information and low communication costs improve business to business communications and lead to lower coordination costs and better decision making. Also, higher utilization of equipment and reduction of inventories reduce operational costs and induce reorganization of production and distribution of goods and services. Other benefits include low transaction costs, price transparency and low search costs for firms and individuals.³

2.2. Empirical literature

There is a large literature which explores the influence of either ICT or competition on productivity and efficiency. Early empirical studies conducted at the firm level (Lee and Barua, 1999; Becchetti et al., 2003) or at the cross country level (Thompson and Garbacz, 2007) have provided evidence in favor of a positive link between ICT and productive efficiency. These results have also been confirmed recently for a sample of developed and developing countries (Dimelis and Papaioannou, 2011). Similarly, Van Ark et al. (2003) and Inklaar et al. (2008) have verified the significant impact of ICT on growth and productivity in both the USA and the EU.

Most of the existing empirical literature has established a positive relationship between productivity and competition. Nickell (1996) as well as Nickell et al. (1997) have shown that higher competition exerts a positive impact on UK firm level Total Factor Productivity (TFP). Blundell et al. (1999) showed that policies in favor of competition are an important factor for the improvement of productivity. Nicoletti and Scarpetta (2003) evidenced that entry liberalization involves significant productivity gains for all industries of OECD countries, irrespective of their position vis-a-vis the technology frontier. They also show that productivity gains are greater in manufacturing industries of countries being far from the technology frontier. Similarly, Conway et al. (2006) suggest that the productivity gains from product market reforms could be considerably high for countries that are lagging behind the frontier.

Aghion et al. (2004) showed that entry liberalization in the UK during the 1980s has led to faster total factor productivity growth of domestic incumbent firms and improved aggregate productivity performance. Inklaar et al. (2008) found that entry liberalization has been beneficial for productivity growth only in telecommunications, but not in other service industries. Aghion et al. (2009) argued that market rigidities and employment protection legislation are significantly related to TFP growth when a country is close to

² Parente and Prescott (1994) assumed a model of technology adoption where the decision of a firm to invest in technology depends on the degree of legal and regulatory barriers, the existence of which increases the cost of technology adoption. Alesina et al. (2005) argue that fewer regulations lower the cost of expanding capital stocks of firms and argue that the cost of reorganizing the production process after adoption of a new technology is lower in regulatory friendly environments. The empirical results of Gust and Marquez (2004), Conway et al. (2006), as well as Van Ark et al. (2008) verify that differences in the regulatory environment have a strong impact in the decisions of firms to adopt new technologies.

³ Bresnahan and Trajtenberg (1995) consider ICT as a major technological breakthrough which shares all characteristics of general purpose technologies while Jovanovic and Rousseau (2005) consider it as an enabling technology.

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