The Impact of Telecommunication Technologies on Competition in Services and Goods Markets: Empirical Evidence*

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Abstract
In this paper, we empirically show that a more intensive use and wider adoption of telecommunication technologies significantly increases the level of product market competition in services and goods markets. Our results are consistent with the view that the use of telecommunication technologies can lower the costs of entry and search. These findings are robust to various measures of competition and a wide range of specification checks.

Keywords: Product market competition; telecommunication technologies

JEL classification: L16; O25; O33

I. Introduction

...[I]n most of the economy IT will help to increase competition.

Broadly speaking, the Internet reduces barriers to entry, because it is cheaper to set up a business online than to open a traditional shop or office. The Internet also makes it easier for consumers to compare prices. Both these factors increase competition. (A Survey of the New Economy: Knowledge is Power, The Economist, September 21, 2000)

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The Internet is a type of telecommunication technology. Conjectures such as the above quote from The Economist indicate that there can be a positive relationship between the more intensive use and the wider adoption (hereafter, diffusion) of telecommunication technologies and competition in services and goods markets (for similar conjectures, see Leff, 1984; Freund and Weinhold, 2004; Czernich et al., 2011).

In this study, we empirically investigate the effect of the country-wide diffusion of telecommunication technologies on the competition in services and goods markets. In order to alleviate endogeneity concerns, we use a difference-in-differences framework in the spirit of Rajan and Zingales (1998). More specifically, we ask whether in countries with higher diffusion of telecommunication technologies, the intensity of product market competition is different in the industries that depend more on these technologies compared to the industries that depend less. We use input–output matrices to measure the dependence on telecommunication technologies of industries. Our main measure of the diffusion of telecommunication technologies is the number of fixed-line and mobile telephone subscribers per capita. It captures the adoption and use of telecommunications in the economy (e.g., Röller and Waverman, 2001). In turn, the main measure of product market competition is the price–cost margin (PCM). We use evidence from 21 European countries to establish our results.

Our results suggest that the diffusion of telecommunication technologies has a strong positive effect on the intensity of competition in services and goods markets. This finding is robust to various measures of competition, dependence, and diffusion. It is also robust to a wide range of specification checks and alternative identification assumptions, where we tackle further the endogeneity concerns. It supports conjectures such as in the above quote from The Economist.

To get a sense of the magnitude of the effect, consider the PCM differential between industries at the 75th percentile (Real Estate Activities) and at the 25th percentile (Manufacture of Other Transport Equipment) of the distribution of dependence on telecommunication technologies. Our estimates imply that this differential is higher by 0.02 in a country at the 25th percentile (such as Estonia) of the distribution of telecommunication-technology diffusion than in a country at the 75th percentile (such as France). This differential is economically sizable. For instance, it constitutes the 11 percent of the sample mean of the PCM.

According to the standard theoretical inference, our results imply that the diffusion of telecommunication technologies increases allocative efficiency in the economy because it intensifies competition. Our results also imply that, through the same channel, the diffusion of telecommunication technologies can lead to productivity gains (Nickell, 1996; Syverson, 2004).
and increase innovative activity (Blundell et al., 1999; Aghion et al., 2005; Griffith et al., 2010).

This study contributes to the ongoing debate about the impact of telecommunication technologies, as well as of information and communication technologies (ICT), on economic performance. Macro-level empirical studies suggest that the diffusion of these technologies has a positive impact on the development level and growth (e.g., Röller and Waverman, 2001; Jorgenson and Vu, 2005). Micro-level empirical studies, in turn, find that the use of telecommunication technologies and ICT can reduce price dispersion and average prices (e.g., Brynjolfsson and Smith, 2000; Brown and Goolsbee, 2002; Jensen, 2007). There can be various drivers behind these results. For instance, the literature on the economics of ICT (e.g., Jorgenson et al., 2005) emphasizes the productivity improvements/cost reductions that stem from the “direct” application of ICT (e.g., the switch from mail to e-mail). In addition, in the literature on the economics of telecommunications, it is argued that the use of these technologies can improve access to information, and reduce distortions and frictions in the markets (e.g., Leff, 1984; Jensen, 2007). Our empirical findings offer support for these conjectures. They imply that the diffusion of telecommunication technologies intensifies the competition in services and goods markets (i.e., reduces mark-ups). Meanwhile, given that the latter can matter for allocative and productive efficiency, our results suggest another driver behind the results of these macro- and micro-level empirical studies. In this respect, our results contribute to the literature on general ICT, and they indicate that the economic benefits from a particular type of ICT (i.e., telecommunication technologies) might come not only from direct use, but also from intensified competition.

This inference can have implications for growth accounting and, specifically, for accounting the contribution of ICT to growth. For example, Oliner et al. (2008) argue that the contribution of ICT to labor productivity growth in US industries has sharply declined recently (see also Acemoglu et al., 2014). The authors also offer evidence that increased competitive pressures explain a significant portion of recent growth. Our results highlight the possible role of ICT in increased competitive pressures in US industries, and suggest that growth accounting exercises, which do not take into account this role, can understate the contribution of ICT to growth.

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1 Aghion et al. (2005) find an inverted U-shaped relationship between the innovative activity and the intensity of competition. Therefore, according to Aghion et al. (2005), our results imply higher innovative activity at least for low levels of competition.

2 Ellison and Ellison (2005) summarize this body of literature and conclude that modern communication technologies are unlikely to lead to “frictionless commerce”. Our results suggest that these technologies reduce frictions in commerce, although we do not observe mark-ups falling to zero.

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The results of this study can also be interesting for policy-makers. They imply that policies that motivate the higher use and wider adoption of telecommunication technologies can complement competition/antitrust policies.

Having mentioned what we identify in this study, it is also worth mentioning what we do not intend to identify. The diffusion of telecommunication technologies can reduce some of the costs of entry and search. However, it is ultimately the corresponding changes in firms’ and consumers’ behavior that would affect the level of competition. Given the data we have, we cannot identify, or aim to identify, exactly how those changes happen.

In addition to the literature on the economics of ICT and telecommunications, this paper is related to studies that examine the determinants of product market competition. Although competition seems to be an important engine of economic activity, to the best of our knowledge, there are very few such studies. There is evidence, for example, that railroad networks intensified competition in the US shipping industry in the 19th century (Holmes and Schmitz, 2001). There is also evidence that regulations can affect product market competition (e.g., Fisman and Allende, 2010; Griffith et al., 2010). Our paper is related to these studies to the extent that telecommunication technologies, similar to the railroad, are general purpose technologies. Moreover, according to our results, the policies that promote the diffusion of telecommunication technologies affect the intensity of competition.

The remainder of the paper is organized as follows. In Section II, we describe the theoretical background, we discuss the motivation for the methodology, and we formally define the objective of this study. In Section III, we describe the data and their sources. In Section IV, we summarize the results, and we conclude in Section V.

II. Theoretical Background and Methodology

How Telecommunications Can Matter

Primarily, we are interested in whether the diffusion of telecommunication technologies has a statistically and economically significant effect on product market competition. In this section, we briefly discuss how this can happen. We emphasize the channels that seem to be following from the literature in the most straightforward manner.

The entry and the potential entry of firms and entrepreneurs into a market can strengthen competition. The costs of entry involve, in particular, the costs of acquiring information about the market (Hurkens and Vulkan, 2001) and the costs of investments in infrastructure. It seems that it is a
common thought in the literature that the use of telecommunication technologies can reduce the information acquisition costs (e.g., Leff, 1984; Röller and Waverman, 2001; Jensen, 2007). The reduction of information acquisition costs can further help the entrants to find the best deals for infrastructure investments. This suggests that the diffusion of telecommunication technologies can reduce the costs of entry.

Arguably, the diffusion of telecommunication technologies can also reduce the firms’ operating costs, because, for example, it can improve information flow and management (e.g., Leff, 1984). This can lower the minimum profitable scale of firms and motivate entry.

Another plausible channel operates through the demand for services and goods. The diffusion of telecommunication technologies can reduce the search costs of consumers, entrants, and (downstream) firms. This might increase the intensity of competition because of better arbitrage (e.g., Waterson, 2003; Pereira, 2005).

The arguments that suggest a positive relation between the diffusion of telecommunication technologies and the intensity of competition are in line with the conjectures of, for example, Freund and Weinhold (2004) and Czernich et al. (2011). However, they might not be fully evident. It can also be argued that the diffusion of telecommunication technologies can help firms to gain market power. For example, it can help firms to increase product differentiation through the advertisement of products over telecommunication networks, such as the Internet. Moreover, lower information acquisition costs can help firms to learn about the demand and the general market environment. Therefore, they can help to increase price discrimination and product differentiation. Lower search costs can also hamper competition. For example, they can increase the likelihood of collusion, especially if the collusion monitoring of firms improves together with the decline of consumers’ search costs (Campbell et al., 2005).

The possible existence of countervailing channels suggests that it can also be insightful to learn the sign of the relationship between the diffusion of telecommunication technologies and product market competition. The diversity of these channels supports our focus on economy-wide diffusion of telecommunication technologies. For brevity, in the remainder of the paper, we highlight the potential role of the diffusion of telecommunication technologies for firm entry as it might be easier to associate with firm behavior and competition. Importantly, this does not obstruct our further theoretical inference.

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3 Freund and Weinhold (2004) hypothesize that the diffusion of telecommunication technologies and, in particular, of the Internet can reduce the costs of entry. Further, they offer a stylized model, where the reduction of entry costs induces the entry of firms and increases the intensity of competition.
Methodology

In this paper, we identify the effect of the diffusion of telecommunication technologies on the competition in services and goods markets. Doing so is not straightforward, however. According to many theoretical models, the level of competition matters for resource allocation in the economy. In turn, this can affect the country-wide diffusion of telecommunication technologies, creating a reverse link. Moreover, various (unobservable) country-level variables can affect competition and correlate with the diffusion of telecommunication technologies.

Nevertheless, there is an intuitive variation that can be used in order to alleviate these concerns. The effect of the diffusion of telecommunication technologies on the costs of entry would be different for industries that depend more heavily on these technologies compared to industries that depend less. Such variation can arise because the industries that depend more heavily on telecommunication technologies $ceteris paribus$ would increase their demand for these technologies more because of that diffusion. In turn, in line with the arguments offered in Leff (1984) or Jensen (2007), the increased demand can result in more information about the industry. An observation that supports these arguments is that telecommunication technologies are used exactly for transmitting and disclosing information. A further supporting observation is that nowadays, for instance, computer producers and retailers seem to be more widely known than the core manufacturers, when the former use significantly more of these technologies. According to these arguments, the diffusion will alter the information acquisition costs disproportionately in industries that depend more heavily on telecommunication technologies. We offer a simple theoretical model that delivers predictions in line with this inference in Online Appendix B.

Our test looks for exactly such a disparity. We test whether in countries with a higher diffusion of telecommunication technologies the level of product market competition is different in industries that depend more on these technologies compared to industries that depend less. One of the advantages of this test is that we need not explain the country-level drivers behind the diffusion of telecommunication technologies – market or regulatory – and our inference would not depend on country-level models of competition. Our test also permits country and industry fixed effects, which can be important for capturing, for instance, institutional and regulatory differences, and the variation in the fixed costs of entry into different industries.

To implement this test, our dependent variable is the level of product market competition in industry $i$ and country $c$ (averaged over the sample period). After controlling for industry and country fixed effects, in our empirical specification we should find that the coefficient on the interaction between the level of the diffusion of telecommunication technologies and
industries’ dependence on those technologies is different from zero. We also
correct for the initial share of an industry in a country in total output, which
can capture potential convergence effects. For instance, it can correct for
the possibility that the larger industries in a country experience lower entry
rates (Klapper et al., 2006), which can affect the intensity of competition.

Our (baseline) empirical specification is then

\[ \text{Competition}_{i,c} = \alpha_1 + \alpha_2 + \alpha_3 \times \text{diffusion in country } c + \alpha_4 \times \text{industry share}_{i,c} + \eta_{i,c}, \]

(1)

where \( \alpha_1 \) and \( \alpha_2 \) are the industry and country fixed effects, and \( \eta_{i,c} \) is the
error term. Our focus is on the coefficient of the interaction term, \( \alpha_3 \). This
coefficient indicates whether countries with a higher diffusion of telecom-
munication technologies have a different level of competition in industries
that depend more on these technologies. It is positive (negative, if we use
an inverse measure for competition) if the diffusion of telecommunication
technologies intensifies competition.

III. Measures and Data

We employ data for 21 European countries and we focus on the period
1997–2006. We focus on these countries because they are fully covered by
the OECD STructural ANalysis (OECD STAN) and Amadeus databases,
which we use to construct the measures of competition.

The use of data from a rather homogeneous set of countries involves
trade-offs. It can eliminate the influence of various unobservable factors on
our inference, for example. However, at the same time, it can weaken our
inference from cross-country comparisons.

Diffusion of Telecommunication Technologies

Our main measure for the diffusion of telecommunication technologies
is the number of fixed-line and mobile telephone subscribers per capita in
1997 (hereafter, Telecom Diffusion).\(^4\)\(^5\) This measure indicates the adoption
and use of telecommunication technologies in the economy, and it is ex-
tensively used in that context. For example, Röller and Waverman (2001)
use a similar measure to show that the diffusion of telecommunication

\(^4\) The use of a sample initial value helps us to alleviate further the reverse causality concerns.
\(^5\) The addition of Internet subscribers can lead to significant double counting because, for
example, fixed lines are used extensively for dial-up and DSL Internet. Nevertheless, we
have checked that our results remain qualitatively the same if we use the per capita number
of Internet subscribers as a measure of diffusion.
technologies increases the rate of economic growth. Clearly, however, at least some part of the use measured in this manner will be hard to associate with the competition in services and goods markets. An example would be a casual conversation over the telephone. Such a variation in the data can bias our results toward zero.

We obtain the data for this measure from the database of the International Telecommunication Union (ITU) and the Global Market Information Database (GMID) of the Euromonitor International, a market research provider. Table A1 in the Appendix at the end of the paper offers basic statistics for the main variables, which are described in detail in Table A2 in the Appendix. Tables A3–A10 in Online Appendix C and Table A16 in Online Appendix D offer correlations, basic statistics, and descriptions of additional data.

**Dependence on Telecommunication Technologies**

In a country, a naïve measure of an industry’s dependence on telecommunication technologies (hereafter, Telecom Dependence) would be its share of expenditures on telecommunications out of total expenditures on intermediate inputs. The problem with this measure is that it reflects both the supply and the demand of those technologies when we need only the demand.

To alleviate this problem, as in the rest of the literature following Rajan and Zingales (1998), we identify the industries’ dependence on telecommunication technologies from US data. Such a measure would be a valid proxy if the rank ordering of the expenditure share on telecommunications in US industries corresponds to the rank ordering of the technological dependence of the industries. We also need that rank ordering to carry over to the rest of the countries in our sample. From another perspective, if our measure is noisy, our findings might only suffer from attenuation bias.

The data for the share of expenditures on telecommunications out of total expenditures on intermediate inputs in US industries are at the two-digit industry level, and they come from the input–output (I–O) tables of the Bureau of Economic Analysis (BEA). The original data are in the North American Industry Classification System (NAICS) 2007. We transform these data to International Standard of Industrial Classification, rev. 3.1 (hereafter, ISIC), in order to align them with the rest of our data, and we exclude the industries that are expected to have a large state involvement (80, 85, 90, and 91 of ISIC). Further, we average these data over the period 1997–2006, and we use the average as a measure for dependence.

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6 Our results are robust to their inclusion.

7 Our results remain qualitatively the same when we use expenditures on telecommunications relative to output (the so-called technical coefficients) and the coefficients of the inverse Leontief matrix as measures of dependence (see Table A11 in Online Appendix C).

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To gain confidence about the validity of our measure, we perform a simple analysis of variance (ANOVA) exercise on our data for the share of expenditures on telecommunications out of total expenditures on intermediate inputs in US industries. Industry-level variation accounts for 99.48 percent of the total variation, and time variation accounts for only 0.52 percent. This provides support for the validity of our measure, suggesting that technological differences are the likely driver behind its variation. Further, we obtain the share of expenditures on telecommunications out of total expenditures on intermediate inputs in the industries from the countries in our sample from the OECD STAN database. These data have a structure similar to the two-digit ISIC, although they are more aggregated and are available only for 1995, 2000, and 2005. We take the average of these three years, and we compute rank correlations between our dependence measure and these shares. The rank correlations are highly significant and range from 0.6 to 0.9 with a mean of 0.8, which provides further support for the validity of our measure (see Table A8 in Online Appendix C).

**Intensity of Competition and Industry Share**

We use five measures of product market competition averaged over the period 1997–2006. These measures are the most widely applied in the literature.

Following Nickell (1996) and Aghion et al. (2005), our primary (inverse) measure of product market competition is the PCM. Under the assumption of constant marginal cost, it is the empirical analogue of the Lerner index. Therefore, it tends to be the reference competition measure, and it has been widely applied in recent empirical work.

Using industry-level data, the PCM is a weighted sum of Lerner indices in the industry across firms, where the weights are the market shares of the firms. In industry \(i\), country \(c\), and at time \(t\), the PCM is given by

\[
PCM_{i,c,t} = \frac{(Revenue - Variable\ Cost)_{i,c,t}}{Revenue_{i,c,t}},
\]

where the variable costs include labor compensation and expenditures on intermediate inputs.\(^8\)

Our second (inverse) measure for the intensity of competition is the profit elasticity (PE), introduced by Boone (2008), which captures the relation between profits and efficiency. It can be argued that this relation

\(^8\) We follow Nickell (1996) and Oliner et al. (2008) while specifying the PCM. In contrast, if we followed Aghion et al. (2005), in the numerator we would have net operating surplus minus financial costs. We do not prefer that measure as we have fewer data for it. Meanwhile, it is highly correlated with our measure \((\rho = 0.7)\), and our results are qualitatively the same with it.
becomes steeper as competition intensifies, because in a more competitive environment the same percentage increase in costs reduces the profits more. In a given pair of industry and country, and for all time periods, the PE is estimated using the following empirical specification,

$$\ln \text{Profit}_{f,t} = \beta_{1,f} + \beta_{2,t} + \beta_{3,t} \ln \left( \frac{\text{Variable Cost}}{\text{Revenue}} \right)_{f,t} + \eta_{f,t},$$  

(2)

where $f$ indexes firms, and $\eta_{f,t}$ is an error term. The PE in industry $i$, country $c$, and time $t$ is the estimated coefficient $\hat{\beta}_{3,i,c,t}$.

The third (inverse) measure is the Herfindahl index (HI), which is defined as the sum of the squared market shares of firms within an industry. Formally,

$$HI_{i,c,t} = \sum_{f=1}^{N_{i,c,t}} \left( \frac{\text{Revenue}_{f,i,c,t}}{\sum_{f=1}^{N_{i,c,t}} \text{Revenue}_{f,i,c,t}} \right)^2,$$

where $N$ is the number of firms. The fourth measure is the market share (MS) of the four largest firms in terms of revenues in each industry. Formally,

$$MS_{i,c,t} = \sum_{\tilde{f}=1}^{4} \frac{\text{Revenue}_{\tilde{f},i,c,t}}{\sum_{f=1}^{N_{i,c,t}} \text{Revenue}_{f,i,c,t}},$$

where $\tilde{f} = 1, 2, 3, 4$ are the four largest firms in industry $i$ and country $c$ at time $t$.

The fifth measure of competition is the number of firms in each industry, $N_{i,c,t}$, which might seem to be the most simplistic and disputable. It might relatively firmly approximate the intensity of competition in situations close to symmetric equilibrium.

Even though these measures are widely applied, in certain cases they might not fully reflect the intensity of product market competition. For instance, when the competition intensifies from more aggressive conduct, some firms might leave the market. In such a situation, the HI, which is a concentration measure, can fail, suggesting that the intensity of competition has decreased. In the same situation, a similar problem can arise with the market share of the four largest firms when, for instance, one or several of the largest firms leave the market. Meanwhile, the PCM can fail in such a case when, for instance, inefficient firms leave the market. This would increase the weight of more efficient firms, and can therefore increase

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9 Another possible criticism that applies to concentration measures such as MS and HI is that these are more tied to the geographic and product boundaries of the market in which the firms operate.
the PCM (for further discussion, see Boone, 2008). However, given its definition, this problem is not present in the PE measure of competition. Nevertheless, given that all our measures have a somewhat different nature (i.e., they can reflect different forces behind the intensity of competition), it seems reasonable to use them for robustness checks of our results. It is worth noting also that averaging over time would alleviate some of these concerns as we focus on a rather long-term level of competition.

We take the data for the PCM and the number of firms from the OECD STAN database, and we use the Amadeus database for the remaining measures of competition.

The Amadeus database has several features that need to be highlighted. First, in this database, there are virtually no data for the financial intermediation, insurance, and pension funding industries. Therefore, our analysis for competition measures constructed using the Amadeus database excludes those industries. Second, this database does not cover the universe of firms, and it might not have a representative sample. For instance, according to Klapper et al. (2006), it tends to overstate the percentage of large firms. This can affect the competition measures identified from this database.

Our industry and country fixed effects are likely to reduce such biases; nevertheless, we perform several robustness checks. Klapper et al. (2006) compare the data from Amadeus with data from Eurostat in terms of the within-industry distribution of the size of the firms, and they keep only the industries and countries that are sufficiently close to the data from Eurostat. We have checked that all our results hold for the sample of countries and industries that were employed in Klapper et al. (2006). We have also calculated the PCM from firm-level data from the Amadeus database, and we have checked that all our results hold for the sample of countries and industries where this measure is sufficiently close to its OECD STAN counterpart.¹⁰

Finally, the share of an industry in a country in total (business) output in 1997 is obtained from the OECD STAN database.

IV. Results

In Column 1 of Table 1, we present our main result from the baseline specification (1), which we estimate using the least-squares method. The dependent variable is our main (inverse) measure of intensity of product market competition (i.e., the PCM), averaged over the period 1997–2006. Meanwhile, the interaction term consists of the logarithm of the diffusion

¹⁰In Online Appendix E, we describe the Amadeus database in more detail, and we offer our data-cleaning procedure.
Table 1. Main result and the results for alternative competition measures

|                        | (1)       | (2)       | (3)       | (4)       | (5)       |
|------------------------|-----------|-----------|-----------|-----------|-----------|
| PCM                    | −2.66***  | −29.67**  | −1.58***  | −1.88***  | 17.05***  |
| PE                     | (0.37)    | (12.47)   | (0.54)    | (0.62)    | (3.92)    |
| HI                     | 0.69***   | 17.35***  | −0.25     | −0.59*    | 10.55***  |
| MS                     | (0.26)    | (4.81)    | (0.21)    | (0.34)    | (2.15)    |
| log N                  |           |           |           |           |           |

Telecom Dependence × Telecom Diffusion

|                        |           |           |           |           |           |
| Industry Share         | 0.72      | 0.52      | 0.59      | 0.73      | 0.93      |

Observations 902 844 876 876 818

R² 0.72 0.52 0.59 0.73 0.93

Notes: This table reports the results from the baseline specification (1) for all our measures of product market competition. See Table A2 in the Data Appendix for the definitions and sources of variables. All regressions include industry and country dummies, and they use the least-squares estimation method. Robust (clustered) standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

measure in 1997, Telecom Diffusion, and the measure of dependence on telecommunication technologies, Telecom Dependence.

The estimate of the coefficient on the interaction term is negative and significant at the 1 percent level. Given that smaller values of the PCM correspond to higher competition intensity, this indicates that in industries that depend more on telecommunication technologies, competition is more intensive in countries with a higher diffusion of these technologies. Therefore, the diffusion has a positive effect on the intensity of competition in the services and goods markets.\(^\text{11}\)

Because we have a difference-in-differences estimate, one way to compute the magnitude of our result is as follows. We take the countries that rank in the 25th and 75th percentiles of the distribution of Telecom Diffusion, and we compute the difference between the logarithms of the diffusion levels in these countries. The countries are Estonia (25th) and France (75th) in our sample. Further, we take the industries that rank in the 25th and 75th percentiles of the distribution of dependence on telecommunication technologies, and we compute the difference between the dependence levels. In our sample, these industries are Manufacture of Other Transport Equipment (25th) and Real Estate Activities (75th). Finally, we compute

\[
\hat{\alpha}_3 \times \Delta \text{Telecom Dependence} \times \Delta \log (\text{Telecom Diffusion}),
\]

where Δ stands for the difference operator between the 75th and 25th percentiles. The computed number is −0.02. This means that the difference in the PCM (the intensity of competition) between Real Estate Activities and Manufacture of Other Transport Equipment is lower (higher) by 0.02 in

\(^{11}\) In Online Appendix C, we also find that our results are stronger in countries with a higher quality of telecommunications infrastructure as measured by the broadband subscriptions.
France compared to Estonia. This difference is sizeable, and it constitutes 11 percent of the sample mean of the PCM (0.19).

In an attempt to rule out other explanations for our main result, we conduct a range of robustness checks.

**Alternative Measures for Competition**

We estimate our baseline specification (1) for the remaining four competition measures in order to check whether our results are robust in terms of the competition measure. Columns 2–5 in Table 1 report the results where, all else equal, the dependent variable is correspondingly the PE, the HI, the MS of the four largest firms, and the logarithm of the number of firms in an industry. All the estimates of the coefficients on the interaction terms have the expected signs and are significant at least at the 5 percent level.

We further report the estimation results exclusively for the PCM. However, we have checked that all our results remain qualitatively the same for the remaining measures of competition.

**Alternative Measures for Diffusion and Dependence**

Our measure of the diffusion of telecommunication technologies might not fully reflect the use and the quality of these technologies, which can matter for the costs associated with information transmission. For a robustness check of our results, we also use the revenue of the telecommunications industry per capita as a measure of diffusion, Telecom Diffusion (Revenue). This measure can better account for the use and quality. However, from the between-country-comparison perspective, it might fail to reflect correctly the amount of telecommunication services produced; it could be higher, for example, simply because prices are higher.\(^\text{12}\) We obtain the data for the revenue of the telecommunications industry from the GMID and ITU databases.

Column 1 in Table 2 offers the results where we use the logarithm of the Telecom Diffusion (Revenue) in 1997. The estimated coefficient is negative and significant at the 1 percent level, which complements the result reported in Column 1 of Table 1.

Further, our measure of dependence on telecommunication technologies might fail to identify the technological ranking of industries correctly. Although, according to the rank correlation tests, this is most likely not the case, we perform robustness checks.

\[^\text{12}\] This problem can be alleviated with a purchasing power parity index for the telecommunications industry. We are not aware of any good source of such data. Nevertheless, we have checked that our results are qualitatively not different if we adjust revenues by the price of a three-minute local mobile phone call.
Table 2. **Alternative measures of diffusion and dependence and different samples**

| (1) Revenue JP (OECD) EU | (2) Telecom Dependence [ × Telecom Diffusion (Revenue)] | (3) Telecom Dependence [ × Telecom Diffusion] | (4) Telecom Dependence × Telecom Diffusion | (5) Industry Share | (6) Observations | (7) $R^2$ |
|-------------------------|----------------------------------------------------|---------------------------------|--------------------------------------------|------------------|----------------|--------|
| −1.46*** (0.24)         | −1.16*** (0.22) −1.65*** (0.24) −1.52*** (0.35)    | −3.21*** (0.55) −3.55*** (0.83) −3.00*** (0.61) | −2.97* (1.74) |
| 0.69*** (0.27)          | 0.77** (0.31) 0.82*** (0.31) 0.82*** (0.31)       | 0.72** (0.29) 0.67** (0.28) 0.68* (0.37) | 0.47 (0.40) |
| 902 618 618 618 900 637 | 0.71 0.75 0.75 0.75 0.71 0.70 | 0.68 0.68 | 0.58 0.58 |

**Notes:** This table reports the results from the baseline specification (1) for various measures of diffusion and dependence and sample restrictions. The dependent variable is the PCM, which is averaged over the period 2000–2006 in Column 5, and over the period 1997–2006 in the remaining columns. In Column 1, the diffusion measure is (the logarithm of) the revenues of the telecommunications industry per capita in 1997. In Columns 2 and 3, the measures of dependence are identified from OECD STAN data for Japan and the US. In Column 4, the dependence measure is constructed as the average of an industry's share of expenditures on telecommunications out of total expenditures on intermediate inputs in all European countries from the sample. The data are from the OECD STAN database. All measures of dependence from the OECD STAN database are averaged over the years 1995, 2000, and 2005. In Column 5, Telecom Diffusion and Industry Share are for 2000, and Telecom Dependence is averaged over the period 2000–2006. In Column 6, new members of the European Union (Czech Republic, Estonia, Hungary, Poland, Slovakia, and Slovenia) are excluded from the sample. Column 7 excludes the manufacturing industries. Column 8 excludes industries in a country that have a higher-than-median Telecom Dependence × Industry Share in the country. For samples in Columns 6–8, we perform Chow tests for the coefficients on the interaction terms. The $p$-values of corresponding $t$-statistics are reported in the Chow test row. See Table A2 in the Data Appendix for the definitions and sources of variables. All regressions include industry and country dummies, and they use the least-squares estimation method. Robust (clustered) standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.
For a robustness check, we employ the shares of expenditures on telecommunication technologies out of total expenditures on intermediate inputs in industries in Japan. Similar to the US, this country has a well-developed ICT sector and a relatively high telecommunication technologies diffusion. At the same time, it tends to have a different industrial composition than the US, which would be another type of robustness check.

The data for this measure were obtained from the I–O tables from the OECD STAN database. These data are slightly more aggregated than the data for our main measure, and they are only for 1995, 2000, and 2005. We average the share of the Japanese industries’ expenditures on telecommunications over these three years, and we use it as a measure of dependence in our baseline specification (1).

Column 2 in Table 2 reports the results. The estimate on the interaction term is again negative, which reaffirms our main result. However, it is smaller in absolute value. To check this result, we calculate a measure of dependence using data from the OECD STAN database on US industries. With this measure, the estimate of the coefficient on the interaction term is reported in Column 3 of Table 2. It is very close to the estimate that we obtain using the measure identified from the data for Japan. Moreover, it is quite close to the main result, although it implies a somewhat smaller effect. It is different, however, because the OECD STAN database has a higher industry aggregation.  

In Column 4 of Table 2, we use as a measure of dependence the country–time average of the expenditure share on telecommunications in industries in our sample of European countries. The estimate of the coefficient on the interaction term is not qualitatively different from the main one.

We further report exclusively the results for our main measures of diffusion and dependence. We have checked that all our results are qualitatively the same for these alternatives.

**Non-Parametric Estimator**

In our difference-in-differences estimation, we essentially divide the countries into high diffusion (HDIFF) and low diffusion (LDIFF), and the industries into high dependence (HDEP) and low dependence (LDEP). Abstracting from the control variables, our estimate is

\[ \text{HDEP(HDIFF)} - \text{LDEP(HDIFF)} - \text{HDEP(LDIFF)} - \text{LDEP(LDIFF)} \]

which captures the average effect only. The effect that we compute with this non-parametric estimator is \(-0.03\). This result reassures us that the

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13 We have also estimated the specification (1) using the US measures for the overlapping sample of industries of the BEA and OECD STAN databases. The estimates are very close: \(-1.80\ (0.30)\) and \(-1.09\ (0.20)\), respectively.

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effect we have identified previously is generally present in all countries and industries.

Alternative Explanations: Do We Capture Integration Processes?

Further, we test whether our results are robust to various sample restrictions. First, we restrict our sample to 2000–2006 to check whether the market integration processes in the European Union (EU) affect our results. Column 5 in Table 2 reports the results from the baseline specification. The dependent variable is the PCM and, together with the measure of telecom dependence, it is averaged over the period 2000–2006. The measure of telecommunication technologies diffusion and the industry share variable are from 2000. The estimate of the coefficient on the interaction term is negative and highly significant. Its magnitude has increased in comparison with the main result, but not considerably. This suggests that the integration processes are not likely to be the drivers behind our results.

Alternative Explanations: Are New Members of the European Union Different?

The former transition countries (Czech Republic, Estonia, Hungary, Poland, Slovakia, and Slovenia), which joined the EU in 2004, can be different from the remaining countries in our sample. In these countries, the privatization process has resulted in the emergence of a large number of private firms (Klapper et al., 2006). Moreover, these countries have gone through large structural/industry changes. The latter can affect the intensity of competition, whereas the former can affect the patterns of telecommunication-technology use. We want to make sure that our results are not driven by these factors.

Column 6 in Table 2 reports the results when we exclude these countries from the sample. The estimate of the coefficient is not significantly different from the main estimate according to the Chow test.

Alternative Explanations: Are the Services Industries Different?

The processes behind our results might be different in the services industries compared to the goods/manufacturing industries. This is because

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14 Our results are virtually the same if we consider the periods 1998–1999 and 1996–2005. Our results also do not change when we add to our specification the interaction between Telecom Dependence and the ratio of imports and exports to GDP, which can capture integration processes. Similarly, they do not change when we add the interaction between Telecom Diffusion and the ratio of industry-level imports and exports to output. (The data for imports and exports are from OECD STAN and OECD Stat.)
services products can be more easily marketed and delivered over telecommunication networks. Therefore, in line with the literature on electronic versus regular marketplaces, it might be reasonable to expect the role of the consumers’ search costs to be different for the services industries. These costs might be important as they can affect the intensity of competition (Campbell et al., 2005; Pereira, 2005). Although theory does not have a clear-cut inference on the direction of the effect, empirical studies point out that lowering consumers’ search costs increases the intensity of competition (e.g., Brown and Goolsbee, 2002).

Column 7 of Table 2 reports the results when we restrict the sample to the services industries. The estimate of the coefficient is essentially the same as our main estimate. In turn, the simple Chow test suggests that there is no significant difference between the services and the goods industries.

**Alternative Explanations: Are the Industries That Use Telecommunications Least Any Different?**

We have also checked that our results are not qualitatively different from the main result for the industries that most likely affect the diffusion of telecommunication technologies the least. To identify such industries, we take the interaction between the variables Industry Share and Telecom Dependence, and for a country we take those industries that have a value lower than the median in that country.

Column 8 of Table 2 reports the results. The coefficient for the industries that have lower-than-median interaction between Telecom Dependence and Industry Share is essentially the same as our main result. This exercise suggests that our results are not likely to be driven by reverse causality. Nevertheless, we continue to explore such a possibility.

**Reverse Causality**

Our inference would be incorrect if a third factor is responsible for the intensity of competition, and if it is correlated with the interaction between dependence and diffusion measures. In this section, we attempt to rule out such an explanation of our results.

First, we try to alleviate further the reverse causality concerns and to instrument the pre-determined level of the diffusion of telecommunication technologies. The set of instruments that we use consists of dummy variables for country groups: countries that joined the EU in 2004, Scandinavian countries, and France–Germany. The first set of countries inherited (antiquated) telecommunications infrastructure from their socialist regimes. Scandinavian countries, in turn, were very effective in promoting universal access via state control and subsidies after deregulation. Meanwhile, France
and Germany had the best access to mobile technologies through industry leaders such as La Compagnie Générale d’Électricité and Siemens. Column 1 in Table 3 reports the results, which are no different from our main results.\textsuperscript{15}

Our country-group-level instrumental variables might not solve the endogeneity problem, however. It might be that they are correlated with some omitted variables and therefore do not satisfy the exclusion restrictions.

\textbf{Omitted Variables: Do We Identify Other Costs of Entry?}

According to, for example, Klapper \textit{et al.} (2006), the country groups that comprise our instruments are quite different in terms of variables that matter for entry (and potential entry) and for the size distribution of firms and, thus, for the intensity of competition. Following Klapper \textit{et al.} (2006) and Scarpetta \textit{et al.} (2002), these variables are the bureaucratic costs of entry, product market regulation, financial development, the regulation of labor, property rights, and human capital development (or the availability of qualified personnel). To the extent that the diffusion of telecommunication technologies is correlated with these variables (e.g., because it reflects the business environment), and that the rank of telecom dependence is correlated with the rank of the industries that are mostly affected by these variables, our inference would be incorrect.

We follow the literature to find measures for these country-level variables and to identify the ranking of industries according to the effect these variables should have on them (i.e., on the competition in those industries). We then include the interactions between these variables in the baseline specification.

We obtain the measure and the data for the bureaucratic costs of entry from Djankov \textit{et al.} (2002). To measure the country-wide market regulation, we use the product market regulation indicator from OECD Stat. We measure the level of financial development as stock market capitalization over GDP, and we take the data from the World Development Indicators (WDI) database. The measure and data for the regulation of labor are from Botero \textit{et al.} (2004). Furthermore, the property rights index constructed by the Heritage Foundation is used to proxy for property rights and their enforcement. Given availability, the data for these measures are for 1999, 1997, 1997, 1998, and 1997, respectively. Finally, we use the average years of schooling for the population older than 25 as a measure of human capital development. The data are for 1995, and we obtain them from the

\textsuperscript{15} Röller and Waverman (2001) use the waiting list for main lines per capita as an instrumental variable. Our results are robust to using this variable, both together with our instrumental variables and separately.
Table 3. Specification check: instrumental variables and additional variables

|                          | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       | (7)       |
|--------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
|                          | IV        | Bureaucratic Entry Costs | Market Regulation | Financial Development | Labor Regulation | Property Rights | Human Capital |
| Telecom Dependence       | −2.78***  | −2.67***  | −3.05***  | −2.93***  | −1.68***  | −2.90***  | −2.91***  |
| × Telecom Diffusion      | (0.40)    | (0.41)    | (0.52)    | (0.36)    | (0.32)    | (0.36)    | (0.36)    |
| Entry Rate               | 0.01      | 0.00      | 0.00      | 0.02      | 0.00      | 0.00      | 0.00      |
| × Bureaucratic Entry Costs |          |           |           |           |           |           |           |
| External Financial Dependence | 0.02      |           |           |           |           |           |           |
| × Financial Development  | (0.02)    |           |           |           |           |           |           |
| Labor Intensity          | 2.33      |           |           |           |           |           |           |
| × Labor Regulation       | (5.25)    |           |           |           |           |           |           |
| R&D Intensity            | 0.00      |           |           |           |           |           |           |
| × Property Rights        | (0.01)    |           |           |           |           |           |           |
| R&D Intensity            | 0.00      |           |           |           |           |           |           |
| × Human Capital          | −0.02     |           |           |           |           |           |           |
| Industry Share           | 0.67***   | 0.75***   | 0.83***   | 0.69***   | 0.74***   | 0.70***   | 0.73***   |
|                          | (0.25)    | (0.26)    | (0.27)    | (0.27)    | (0.23)    | (0.27)    | (0.27)    |
| Observations             | 902       | 803       | 721       | 882       | 462       | 882       | 882       |
| $R^2$                    | 0.72      | 0.73      | 0.71      | 0.73      | 0.84      | 0.73      | 0.73      |

Notes: The dependent variable is the competition measure PCM in regressions reported in this table. Column 1 reports the results from the baseline specification, which we estimate using instrumental variable techniques (two-step generalized method of moments). The instrumental variables are dummy variables for country groups: countries that joined the EU in 2004 (the new members of the EU), Scandinavian countries (Denmark, Norway, and Sweden), and France/Germany. The $p$-value of the first-stage $F$-stat is 0.00. Columns 2–7 report the results from specifications that augment the baseline with additional interaction terms. See Table A2 in the Appendix for the definitions and sources of variables. All regressions include industry and country dummies and, in Columns 2–7, they use the least-squares estimation method. Robust (clustered) standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.
Barro–Lee tables (Barro and Lee, 2013). Table A2 in the Appendix offers detailed descriptions for these measures.

We also need the ranking of the industries according to the effect of these variables on them. The bureaucratic costs of entry, according to Klapper et al. (2006), have a higher impact on entry in naturally high-entry industries. It would be reasonable to expect that product market regulation matters in these industries in a similar way. Meanwhile, financial development, according to Rajan and Zingales (1998), has a higher impact on the creation of new establishments in industries that depend more on external finance. The strictness of labor regulation, in turn, could be expected to have a disproportionate impact on the industries that have high labor intensity. Furthermore, property rights and human capital development would have a disproportionate impact on the industries that have high R&D intensity.

We use the measure and the data of Klapper et al. (2006) to identify the naturally high-entry industries. It is defined as the percentage of new corporations in an industry in the US, and it is averaged over the period 1998–1999 in that paper. We take the measures and the data for dependence on external finance and R&D intensity from Bena and Ondko (2012). The first is defined as the industry median of the average of the ratio of capital expenditures minus cash flows from operations to capital expenditures over the period 1996–2005. Meanwhile, R&D intensity is defined as the industry median of the ratio of averages of R&D expenditures to capital expenditures over the period 1996–2005. As a measure for labor intensity, we use the ratio of the number of employees to output in US industries averaged over the period 1997–2006. We take these data from the OECD STAN database.

In order to check whether any of these variables matter for our results, we create an interaction term and add it to the baseline specification (1). Columns 2–7 of Table 3 report the results. Clearly, the fact that we use data for the years 1999 and 1998 for bureaucratic costs of entry and market regulation can raise further endogeneity concerns. To alleviate these concerns, we have checked that our results are no different when we use data for competition, dependence, and diffusion measures from the period 2000–2006, for example.

The coefficient on the interaction term between the measures of dependence and diffusion remains virtually the same in all cases. However, it decreases in absolute value when we insert the interaction between measures of labor regulation and labor intensity (Column 5). This effect is neither significant nor driven by that interaction term. The coefficient on the interaction term in the baseline specification is virtually the same on the subsample where we have observations of the measures of labor intensity.

\footnote{We are grateful to Peter Ondko for sharing his data with us.}
Table 4. Specification check: additional variables

|                        | (1) Business Environment | (2) Growth Potential | (3) Growth Potential EU | (4) Average Growth |
|------------------------|--------------------------|----------------------|-------------------------|-------------------|
| Telecom Dependence     |                          |                      |                         |                   |
| × Telecom Diffusion    | −2.80***                 | −2.24***             | −2.57***                | −2.37***          |
|                        | (0.39)                   | (0.43)               | (0.37)                  | (0.47)            |
| Telecom Dependence     |                          |                      |                         |                   |
| × Business Environment | 13.06                    |                      |                         |                   |
|                        | (8.80)                   |                      |                         |                   |
| Growth Potential       |                          |                      |                         |                   |
| × Telecom Diffusion    | −0.36**                  |                      |                         |                   |
|                        | (0.16)                   |                      |                         |                   |
| Growth Potential EU    |                          |                      | −0.43***                |                   |
| × Telecom Diffusion    |                          |                      |                         |                   |
|                        | (0.12)                   |                      |                         |                   |
| Average Growth         |                          |                      |                         | 0.11***           |
|                        |                          |                      |                         | (0.04)            |
| Industry Share         | 0.69***                  | 0.68***              | 0.68***                 | 0.93**            |
|                        | (0.26)                   | (0.27)               | (0.26)                  | (0.38)            |
| Observations           | 902                      | 902                  | 902                     | 783               |
| R²                     | 0.72                     | 0.72                 | 0.72                    | 0.73              |

Notes: This table reports the results from specifications that augment the baseline with additional interaction terms. The dependent variable is the competition measure PCM. See Table A2 in the Appendix for the definitions and sources of variables. All regressions include industry and country dummies, and they use the least-squares estimation method. Robust (clustered) standard errors are in parentheses. ***, **, and * indicate significance at the 1, 5, and 10 percent levels, respectively.

regulation and intensity. In turn, the signs of the coefficients of the additional interaction terms tend to be intuitive, although the estimates are not significant.\(^{17}\)

All these additional interaction terms, as well as our main interaction term, can proxy for the business/competitive environment in the country. Another rough way to proxy for that, together with the entrepreneurial culture in the country, is to include an interaction term of the Telecom Dependence variable with the average intensity of competition for the country. Column 1 of Table 4 reports the result when we include such an interaction term in our baseline specification. The coefficient of our main interest remains unaltered.

Another concern is that it can be more valuable to obtain information about the products and prices in more competitive markets, and consumers might form their demand for telecommunications accordingly. The exercise offered above, together with our instrumental variable estimation results and results for industries that use telecommunications least, suggests that

\(^{17}\)It might also be argued that the ranking of the industries according to their dependence on telecommunication technologies corresponds to the ranking of industries according to the effect these variables have on them. We explore this hypothesis in Table A13 in Online Appendix C. In that table, we also report the results when in addition to our main interaction term we include the interaction of Telecom Dependence with a market regulation indicator for the telecommunications industry.

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this is likely not to be a major issue. Nonetheless, we also check that our results remain unaltered for industries that have a lower than median level of competition in their countries; however, these results are not reported.

**Omitted Variables: Do We Identify the Growth Potential of the Industries?**

It could also be that the measure of dependence on telecommunication technologies identifies the industries that have high growth potential. Meanwhile, such industries could depend on the availability of modern technologies, which might be proxied by the diffusion of telecommunication technologies, and they could face tougher competition due to attractiveness.

We follow Fisman and Love (2007) and use the growth rate of output of US industries averaged over the period 1998–2007 as a proxy for the growth potential of the industries. The data are from the Bureau of Economic Analysis. This proxy seems to be the most appropriate given the relatively low market imperfections in the US. However, it could fail if there are important taste differences in the US compared to our sample countries. Therefore, we also use the growth rates of output of industries in the three most developed (measured by GDP per capita in 1997) European countries in our sample averaged over the countries and the 1998–2007 period.

We interact the proxies for growth potential with the measure of diffusion of telecommunication technologies, and we include the interactions in the baseline specification. Columns 2 and 3 of Table 4 report the results. The estimate of the coefficient on the interaction between Telecom Dependence and Telecom Diffusion remains virtually unaffected. The estimated coefficients on the interactions between Telecom Diffusion and the measures of growth potential are negative. This suggests that in countries where the diffusion of telecommunication technologies is higher, the competition is more intensive in industries with higher growth potential. An explanation for this can be that industries with high growth potential depend more on such (modern) technologies (see Table A10 in Online Appendix C for the correlation between the measures of growth potential and dependence on telecommunication technologies). Therefore, a higher diffusion of telecommunication technologies reduces (potential) entry costs in these industries more than in industries with low growth potential.

As a final check, we also include in our baseline specification the growth rates of industries in the European countries from our sample averaged over the period 1998–2007. We report the result in Column 4 of Table 4. Our main result is virtually unaffected. It also remains unaffected if we include all these additional terms at once, but these results are not reported. (We offer results from further robustness check exercises in Tables A11–A14 in Online Appendix C.)
V. Conclusions

In this study, we use industry–country-level data in order to identify the effect of the wider adoption and more intensive use (diffusion) of telecommunication technologies on the competition in services and goods markets. Taken together, our results offer robust evidence that the diffusion of telecommunication technologies significantly intensifies competition. It does so especially in the industries that depend more on these technologies.

According to the theory and empirical evidence, the intensity of product market competition matters for allocative and productive efficiency. Therefore, our results highlight a mechanism for how the use of a particular type of ICT (i.e., telecommunication technologies) can contribute to economic performance. This complements, for example, the productivity improvement mechanism that tends to be extensively emphasized in the literature. From this perspective, our results can have implications for accounting the contribution of ICT to growth in standard growth accounting frameworks, which do not take into account this effect on competition.

Our findings also suggest that the policies intended to promote the diffusion of telecommunication technologies can complement competition policies.

Appendix

Table A1. Summary statistics

| Variable                                | Obs. | Mean   | SD    | Min.  | Max.  |
|-----------------------------------------|------|--------|-------|-------|-------|
| **Country-level variables**             |      |        |       |       |       |
| Bureaucratic Entry Cost                 | 20   | 0.19   | 0.20  | 0.01  | 0.86  |
| Business Environment                    | 21   | 0.19   | 0.02  | 0.15  | 0.23  |
| Financial Development                   | 21   | 0.28   | 0.23  | 0.02  | 0.79  |
| Human Capital                           | 21   | 9.48   | 1.28  | 6.82  | 11.45 |
| Labor Regulation                        | 20   | 0.61   | 0.15  | 0.28  | 0.81  |
| Market Regulation                       | 18   | 2.25   | 0.65  | 1.07  | 3.97  |
| Property Rights                         | 21   | 0.77   | 0.13  | 0.50  | 0.90  |
| Telecom Diffusion                       | 21   | 0.61   | 0.23  | 0.22  | 1.06  |
| Telecom Diffusion (Revenue)             | 21   | 381.16 | 213.09| 85.44 | 863.10|
| **Industry-level variables**            |      |        |       |       |       |
| Entry Rate                              | 44   | 6.15   | 1.76  | 1.74  | 10.73 |
| External Financial Dependence           | 46   | 0.32   | 0.72  | −1.55 | 2.95  |
| Growth Potential                        | 47   | 0.01   | 0.03  | −0.09 | 0.09  |
| Growth Potential EU                     | 47   | 0.05   | 0.05  | −0.06 | 0.22  |
| Labor Intensity                         | 24   | 0.01   | 0.00  | 0.00  | 0.02  |
| R&D Intensity                           | 46   | 0.70   | 1.16  | 0.00  | 4.17  |
| Telecom Dependence                      | 47   | 0.01   | 0.02  | 0.00  | 0.06  |
| Telecom Dependence EU                   | 30   | 0.02   | 0.02  | 0.00  | 0.08  |
| Telecom Dependence JP                   | 30   | 0.02   | 0.02  | 0.00  | 0.09  |
| Telecom Dependence (OECD)               | 30   | 0.02   | 0.02  | 0.00  | 0.10  |

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Table A1. Continued

| Variable                  | Obs. | Mean  | SD    | Min.  | Max.  |
|---------------------------|------|-------|-------|-------|-------|
| Average Growth            | 788  | 0.05  | 0.07  | −0.61 | 0.48  |
| HI                        | 928  | 0.14  | 0.17  | 0.00  | 1.00  |
| Industry Share            | 926  | 0.02  | 0.03  | 0.00  | 0.24  |
| log N                     | 863  | 7.24  | 2.63  | 1.39  | 13.49 |
| MS                        | 928  | 0.45  | 0.27  | 0.02  | 1.00  |
| PCM                       | 902  | 0.19  | 0.13  | 0.01  | 0.89  |
| PE                        | 892  | −5.29 | 3.47  | −20.56| −0.03 |

Notes: This table reports basic statistics for the key variables used in the paper. All variables and data sources are defined in detail in Table A2.

Table A2. Definitions and sources of variables

| Variable                  | Definition and Source                                                                 |
|---------------------------|---------------------------------------------------------------------------------------|
| **Country-level variables** |                                                                                       |
| Bureaucratic Entry Cost   | The bureaucratic cost of obtaining legal status to operate a firm as the share of per capita GDP in 1999. Source: Djankov et al. (2002). |
| Business Environment      | PCM averaged over industries in each country. The data are for 1997. Source: Authors’ calculations using data from OECD STAN (http://stats.oecd.org/). |
| Financial Development     | The ratio of stock market capitalization to GDP in 1997. Source: WDI (http://databank.worldbank.org/wdi). |
| Human Capital             | The average years of schooling of the population 25 years of age or over in 1995. Source: Barro-Lee tables (Barro and Lee, 2013). |
| Labor Regulation          | Index of labor regulations in 1997, taking into account job security, the conditions of employment, and the provisions in laws regarding alternative employment contracts. Source: Botero et al. (2004). |
| Market Regulation         | Product market regulation indicator in 1998, taking into account the public control of business, bureaucratic barriers to entrepreneurship, trade and investment. Source: OECD Stat (http://stats.oecd.org/). |
| Property Rights           | Property rights index in 1997, measuring the protection of private property in a country. Source: The Heritage Foundation (http://www.heritage.org). |
| Telecom Diffusion         | The sum of fixed-line and mobile telephone subscribers per capita in 1997. Source: Authors’ calculations using data from ITU (http://www.itu.int) and GMIID (https://www.euromonitor.com). |
| Telecom Diffusion (Revenue)| The revenue of the telecommunications industry per capita (in 2000 US$) in 1997. Source: Authors’ calculations using data from ITU and GMIID. |
| **Industry-level variables** |                                                                                       |
| Entry Rate                | The percentage of new corporations (firms that are not more than one year old) in US industries, averaged over the period 1998–1999. Source: Klapper et al. (2006) using Dun & Bradstreet. |

(Continued)
Impact of telecommunication technologies on competition

Table A2. Continued

| Variable                        | Definition and Source                                                                                                                                                                                                 |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| External Financial Dependence  | The median of the ratio of capital expenditures minus cash flow from operations over capital expenditures in US industries (where both are averaged over the period 1996–2005 for a firm). Source: Bena and Ondko (2012) using Compustat. |
| Growth Potential               | The annual growth rate of real output of US industries, averaged over the period 1998–2007. Source: Authors’ calculations using data from BEA (https://www.bea.gov/).                                                      |
| Growth Potential EU            | The annual growth rate of real output of industries from the three most developed European countries in terms of real GDP per capita in 1997, averaged over the countries and the period 1998–2007. Source: Authors’ calculations using data from OECD STAN. |
| Labor Intensity                | The ratio of the number of employees to production (in $1000) in US industries, averaged over the period 1997–2006. Source: Authors’ calculations using data from OECD STAN.                                                     |
| R&D Intensity                  | The ratio of median R&D expenditures over median capital expenditures in US industries. Both components are averaged over the period 1996–2005. Source: Bena and Ondko (2012) using Compustat.            |
| Telecom Dependence             | The share of (real) expenditures on telecommunications out of total expenditures on intermediate inputs in US industries, averaged over the period 1997–2006. Source: Authors’ calculations using data from BEA, I–O tables. |
| Telecom Dependence EU          | The share of (real) expenditures on telecommunications out of total expenditures on intermediate inputs in industries in European countries from our sample, averaged over countries and the years 1995, 2000, and 2005. Source: Authors’ calculations using data from OECD STAN, I–O tables. |
| Telecom Dependence JP          | The share of (real) expenditures on telecommunications out of total expenditures on intermediate inputs in industries in Japan, averaged over the years 1995, 2000, and 2005. Source: Authors’ calculations using data from OECD STAN, I–O tables. |
| Telecom Dependence (OECD)      | The share of (real) expenditures on telecommunications out of total expenditures on intermediate inputs in US industries, averaged over the years 1995, 2000, and 2005. Source: Authors’ calculations using data from OECD STAN, I–O tables. |
| Industry–country-level variables | The annual growth rate of real output of industries from European countries in our sample, averaged over the period 1998–2007. Source: Authors’ calculations using data from OECD STAN.                     |
| HI                             | The Herfindahl index is computed as the sum of squared market shares of firms within an industry, averaged over the period 1997–2006. Source: Authors’ calculations using data from Amadeus (https://amadeus.bvinfo.com). |
| Industry Share                 | The ratio of output in an industry in a country to the total (business) output in the country in 1997. Source: Authors’ calculations using data from OECD STAN.                                      |

(Continued)
Table A2. Continued

| Variable                  | Definition and Source                                                                 |
|---------------------------|---------------------------------------------------------------------------------------|
| Least Telecom Users       | Dummy variable that takes a value of 1 for an industry–country pair if the interaction between Industry Share and Telecom Dependence is lower than the median in the country, and zero otherwise. Source: Authors’ calculations using data from OECD STAN and BEA. |
| log\(N\)                  | The logarithm of the number of firms in an industry, averaged over the period 1997–2006. Source: OECD STAN, |
| MS                        | Market share of the four largest firms in an industry, averaged over the period 1997–2006. Source: Authors’ calculations using data from Amadeus. |
| PCM                       | The price–cost margin is computed as revenue (sales) minus intermediate cost and labor costs divided by sales, averaged over the period 1997–2006. Source: Authors’ calculations using data from OECD STAN. |
| PE                        | The profit elasticity in an industry–country pair is the estimate of the coefficient \(\beta_3\) in the empirical specification (3), averaged over 1997–2006. Source: Authors’ calculations using data from Amadeus. |

Notes: The country sample consists of Austria, Belgium, Denmark*, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway*, Portugal, Spain, Sweden*, and the UK (where * identifies the three most developed European countries in terms of GDP per capita in 1997), and the new members of the EU (i.e., Czech Republic, Estonia, Hungary, Poland, Slovakia, and Slovenia). The industry sample (ISIC, rev. 3.1) consists of 10, 11, 13–36, 40, 41, 45, 50–52, 55, 60–63, 65–67, 70–74, 92, and 93. (Industries 65–67 are not in the sample for competition measures constructed using Amadeus data. In OECD STAN data, industries 10–14, 15–16, 17–19, 21–22, 36–37, 40–41, 50–52, 60–63, and 65–67 are merged. Furthermore, these data do not contain industries 92 and 93.)

Supporting Information

The following supporting information can be found in the online version of this article at the publisher’s web site.

Online Appendix

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