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Broadband Access and Markups in Europe

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Broadband Access and Markups in Europe*

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Abstract

What is the relationship between internet (broadband) connectivity shocks, markups, and fixed costs? We address the issue by exploiting a large dataset based on balance sheets of European firms. Broadband shocks raise sales, profits-to-sales ratios, fixed costs, and markups of firms that are large, are more efficient (high TFP) and already bear large fixed costs. For these firms, the shock therefore is expansionary, and firms exploit it to raise profit margins. Firms at the opposite tails of the distribution exhibit a substantially muted response. Our results hint that the shock lowers the cost of entering new markets, inducing some firms to bear larger fixed costs as part of their profit-maximizing strategy.

Keywords: Markup, Broadband, firm performance
JEL: L9, L16, L25

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1 Introduction

Faster and easier internet access is at the root of the Information and Communications Technology (ICT) revolution. Thus, it is no surprise that policymakers have increasingly focused on the deployment of (fast)broadband as a tool to promote innovation and growth (Kruger (2009); European Commission (2010); Hauge and Prieger (2015)). The European Union has made significant public investments aimed at facilitating the rollout of high-speed connections (Darvas et al. (2021); European Commission (2021)).

Internet connections have reshaped consumer behaviour and triggered fundamental changes in trade and the organisation of firms Goldfarb and Tucker (2019), Rong (2022). The bulk of research on the effects of internet connectivity has focused on productivity and growth (see Czernich et al. (2011) and Grimes et al. (2012)). In this paper, we adopt a different perspective, focusing on the response of firms' markups. The issue is important in light of an ongoing debate on the nature and welfare implications of rising markups in the US and in advanced economies, as documented in Diez et al. (2018) and De Loecker and Eeckhout (2018).

According to Edmond et al. (2023), the costs of markups are essentially due to the "uniform output tax" of the average markup and the misallocation of production factors. In a dynamic context, Schumpeterian models (see Peters (2020)) emphasise the role of markups because the accumulation of market power is a key driver behind innovation. In this framework, the innovation of existing products raises market power and markups, but creative destruction allows for the replacement of older firms, which disciplines average markups. The theory predicts that markups, concentration, and misallocation increase as a response to a decline in creative destruction and churning.

Another view suggests that technological changes may lead to increased fixed or sunk costs requiring higher markups. Of particular interest to our study is the possibility that a significant portion of information technology spending takes the form of a fixed cost. Similarly, rising markups could be related to network effects that typically characterise digital platforms Berry et al. (2019) provide a thorough discussion of the relationship between digitisation, increasing concentration and rising markups. Bessen (2020) document the strong link between proprietary information technology investment and industry concentration. De Ridder (2024a) shows that the rise of intangible inputs, such as software, can explain the slowdown in productivity growth, the decline in business dynamism, and the increase in market power. By contrast, faster internet connections enable firms to enter new markets, thereby intensifying competition. Furthermore, internet access is a prerequisite for e-commerce, which reduces consumers' search costs, potentially limiting producers' market power. A priori, the theoretical effect of broadband connectivity on markups is therefore ambiguous.

Empirical evidence is also inconclusive. According to Malgouyres et al. (2021), broadband expansion in France increased firm-level imports and reduced the consumption price index by sizable amounts. Cavallo et al. (2014) found evidence that global firms such as Apple and Ikea tend to adopt a uniform pricing policy between online and offline sales, and across countries using the same currency, where it is easy for consumers to take the international price as a benchmark. Autor et al. (2017) see internet-induced changes, such as easier access to information and the proliferation of information-intensive goods that have high fixed and low-marginal costs (e.g., software platforms and online services) as the key drivers behind the growth in concentration and markups, and the rise of superstar firms, documented in Autor et al. (2020). Calligaris et al. (2024) document a strong correlation between markups and an index of sectoral digital intensity in a large dataset of European firms.

We investigate the effects of European broadband coverage, available at the NUTS3 level, on markup (and fixed costs) growth in a large dataset of European firms, using two measures of download speed. These two variables differ in the expected average download speed, which is defined as broadband and fast broadband, and measure the percentage of households in a region with access to (fast) broadband connections.

We implement our analysis in three steps. In the first one, we follow the theoretical framework presented in Loecker and Warzynski (2012) and recover firm markup estimates from a translog production function as in Ackerberg et al. (2015). To achieve this, we rely on the Orbis global database, provided by Bureau van Dijk, which offers a reliable description of European national economies (see Kalemli-Özcan et al. (2024)). Then, following De Ridder (2024a), we exploit our markup estimates to compute the individual firms' fixed costs. This novel feature of our study enables us to contribute to the debate on the relationship between digital technologies, the changing structure of firms' production costs, and markups. One distinctive feature of our dataset is the combination of a large number of firms, extensive regional coverage, including NUTS3 units, and a time horizon of 2011-2022 over which the effects of broadband connectivity are estimated. This opportunity presents challenges to the definition of our estimation method. We cannot apply standard difference-in-differences methods to identify the causal impact of broadband roll-out treatments because data would be available only for a few episodes in particular countries or regions. For this reason, in the second step, we estimate a dynamic panel that relates fast broadband coverage to its past values and a number of controls. This allows us to recover internet connectivity shocks that we use in the third step, when we investigate the impact of these shocks on markup and fixed costs growth by applying the local projections method of Jordà (2005). In addition to focusing on firms' markups and fixed costs, the local projections method allows us to condition our shocks on firm-specific features, using smooth transition estimates. By doing this, we can address important questions concerning the polarisation of firms' distribution. Is the distinction between high-tech and laggard firms the key to explaining the estimated markup responses to broadband shocks, as hinted in Aghion et al. (2023), or are there other firm's features that matter as well?

Related literature and contribution. A relatively small but significant body of literature studies market concentration and market power in Europe. Both Gutiérrez et al. (2018) and Cavalleri et al. (2019) estimate flat concentration trends using Compustat and ORBIS data, respectively. In contrast, Bajgar et al. (2023), whose study relies on OECD Multiprod data, report a persistent increase in concentration in Europe. Using a confidential dataset, Bighelli et al. (2023) find that concentration increased, but they also document that this reflects increased allocative efficiency rather than greater market power. Some studies focus on markups. Diez et al. (2018) and De Loecker and Eeckhout (2018) report an increase in markups, but Weche and Wambach (2021) report substantial stability between 2007 and 2015.

Our study also contributes to the literature examining European broadband connectivity. Using panel data for a large sample of firms from the Netherlands (2002–2005) and the UK (2001–2005), van Leeuwen and Farooqui (2008) argue that connectivity raises capital deepening but not total factor productivity in the manufacturing and service sectors. A similar conclusion is reached in DeStefano et al. (2018), who focus on the UK. Haller and Lyons (2015) cannot find any significant effect of broadband adoption on firms' productivity in a sample of Irish firms. Gillett et al. (2006) and Cambini et al. (2023) document the positive effect of ultra-fast broadband on the productivity of Spanish and Italian firms, respectively. Canzian et al. (2019) show that broadband connection upgrades are associated with firms' increased total factor productivity in the rural and sparsely populated areas in the Italian Province of Trento. Duvivier and Bussière (2022) investigated the impact of ultrafast broadband on business startups in French rural municipalities between 2013 and 2018, finding that positive effects are limited to municipalities with good initial economic and demographic conditions. Sarachuk and Mißler-Behr (2022) focus on new business creation in Germany, finding that the shift from broadband connectivity to ultrafast speed has a positive and significant effect only for ICT firms. Bertschek et al. (2013) found that ADSL adoption does not increase the labour productivity of German firms.

Our results in a nutshell. The estimated responses of markups,fixed costs, sales, and profits to a broadband shock are unambiguously positive. When we normalize fixed costs and profits by the amount of sales, we obtain that the response of the former to the shock is muted, whereas the latter increase. Our conclusion, therefore, is that the broadband shock is on average expansionary, as evidenced by the increases in both sales and profits, and even if the shock is associated with an increase in fixed costs, on average firms manage to stabilise their ratio to sales and to increase markups. These outcomes are combined with an estimated increase in the profit-to-sales ratio. Smooth transition estimates allow us to highlight important polarisation effects between the lower and upper tails of the firms' distribution for TFP, fixed costs, and size. For each of these categories, we obtain that profits, markups, and fixed costs increase, whereas firms at the opposite tail of the distribution do not seem to react to the shock. These results can be related to the internet-related reduction in the costs of entering new markets, which induces some firms to rely more on increased fixed costs in order to raise their average markups and profitability. One important contribution of our empirical analysis is the identification of a number of firm-specific characteristics that favour the adoption of such a strategy.

The remainder of the paper is organised as follows. Section 2 describes the data used, section 3 illustrates the methodology used to estimate firms' markups, section 4 describes the empirical methodology, section 5 presents the results, and finally section 6 concludes.

2 Data description

2.1 Firms

Firms' balance sheet data are obtained from Orbis Historical, a database provided by Moody's/Bureau van Dijk, which includes harmonised financial and ownership information for private and publicly listed firms in many countries and for an extended period. The data derive from national business registers, varying coverage depending on country-specific legal and administrative filing requirements.[1] After merging it with broadband data, we obtain a dataset of approximately 5 million firm-level observations in 21 European countries, 1010 NUTS3 regions, for the period 2011-2022.[2]

2.2 Broadband and population data

Broadband data was obtained from Point Topic (2024), which provides granular information on broadband access at the NUTS3 level from 2011 to 2022.[3] For each region, we use two measures: the share of households with broadband access capable of realistically achieving download speeds of at least 30 Mbit/s and 100 Mbit/s, respectively. We refer to the former as broadband (BB30) and the latter as fast broadband (BB100).

These measures are complemented by additional variables at the regional level, such as population density, GDP per capita, and the proportion of the population residing in urban/rural areas.

Figures 1 and 2 document the increase in (fast) broadband coverage across the NUTS3

[1] Kalemli-Özcan et al. (2024) have shown that Orbis has good national representativeness in Europe, even for small private firms.

[2] Covered countries are Austria, Belgium, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Hungary, Italy Luxembourg, Norway, Poland, Portugal Romania, Slovakia, Slovenia, Spain, Sweden. Due to the information requirements of our estimation procedure, which is described below, we limit our sample to firms that provide data for at least four consecutive years.

[3] NUTS is the European regional classification taxonomy which defines three major layers. NUTS1: major macro regions. NUTS2: regions (those generally used by the EU for conducting regional policies). NUTS3: small regions.

regions. Figures 3, and 4 document the strong convergence in the degree of broadband coverage, with regions lagging behind in 2011 showing the highest increase in coverage. Evidence for fast broadband coverage is qualitatively similar but less intense. (see Figures 5 and 6).

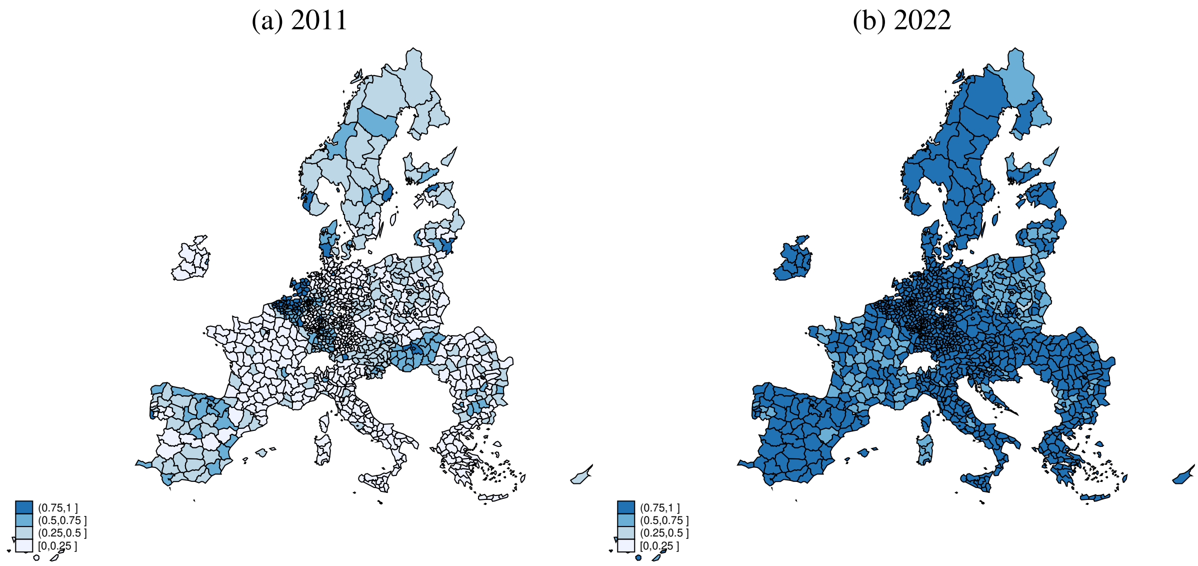


Figure 1: Broadband 30 Mbps coverage

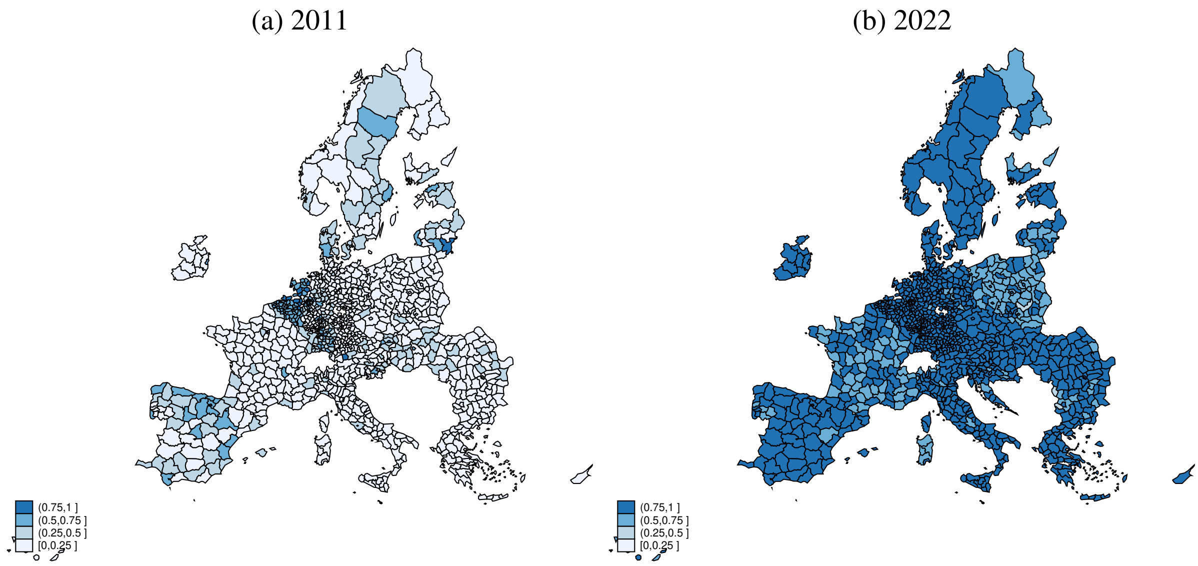


Figure 2: Broadband 100 Mbps coverage

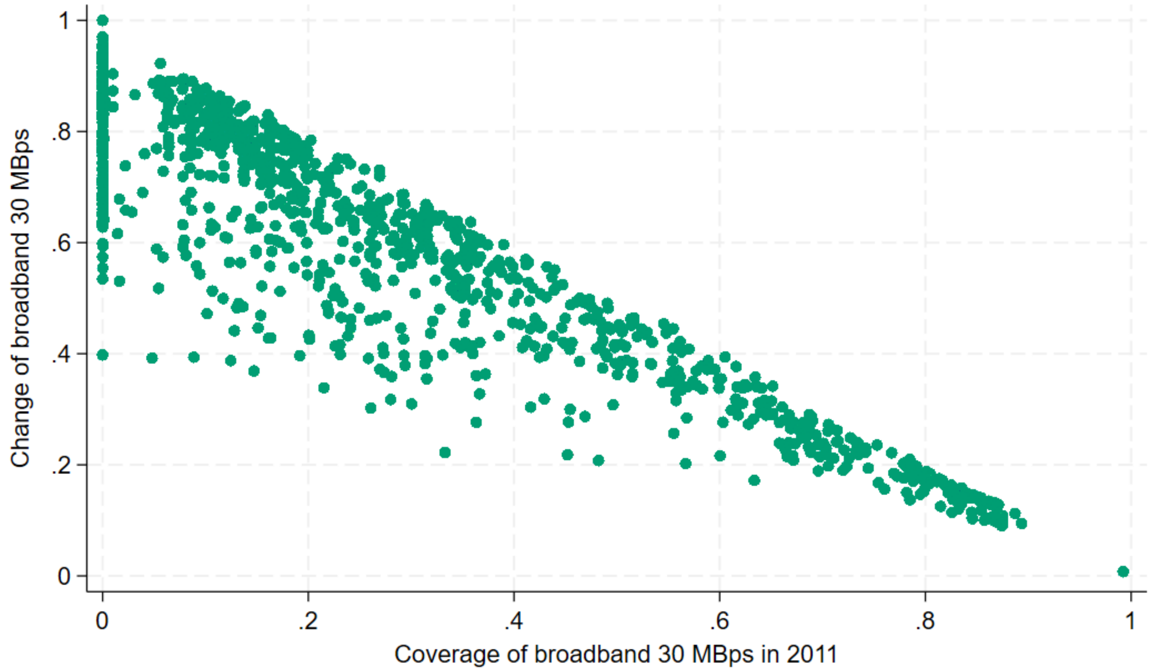


Figure 3: Broadband convergence (30 Mbps), EU NUTS3 regions

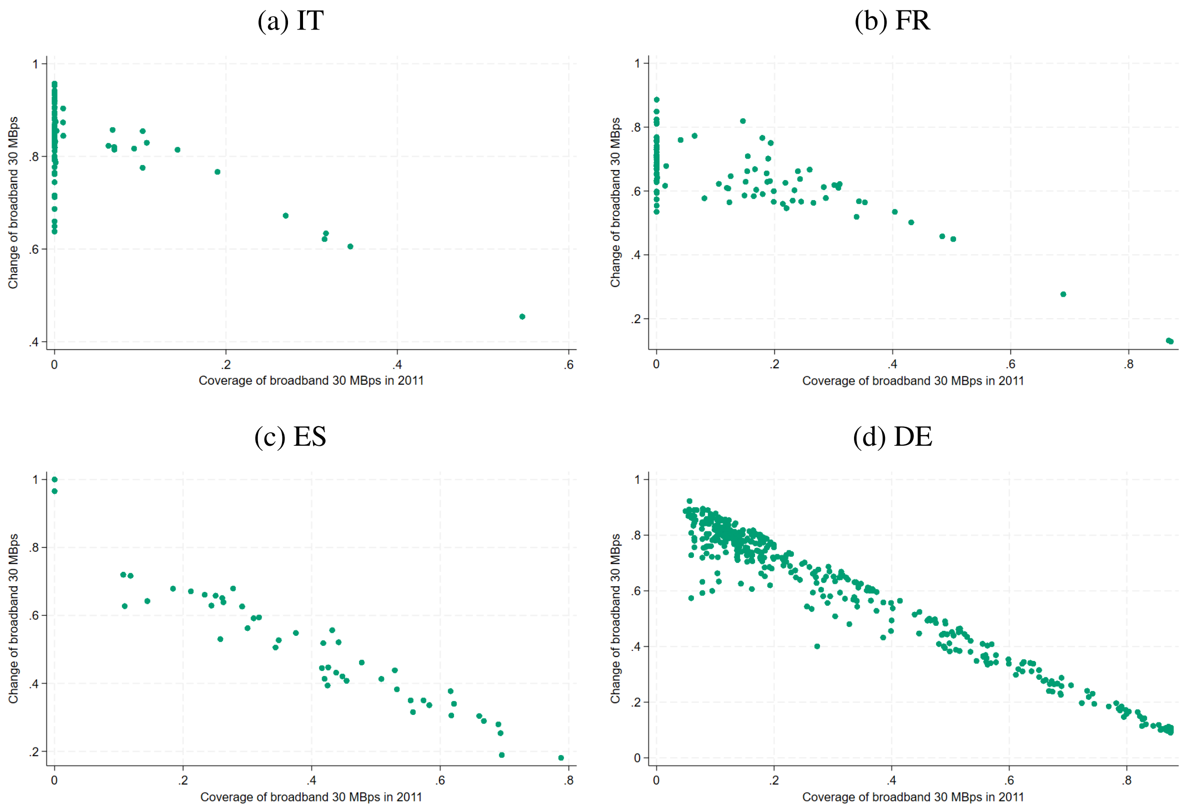


Figure 4: Selected countries. Broadband convergence (30 Mbps), NUTS3 regions

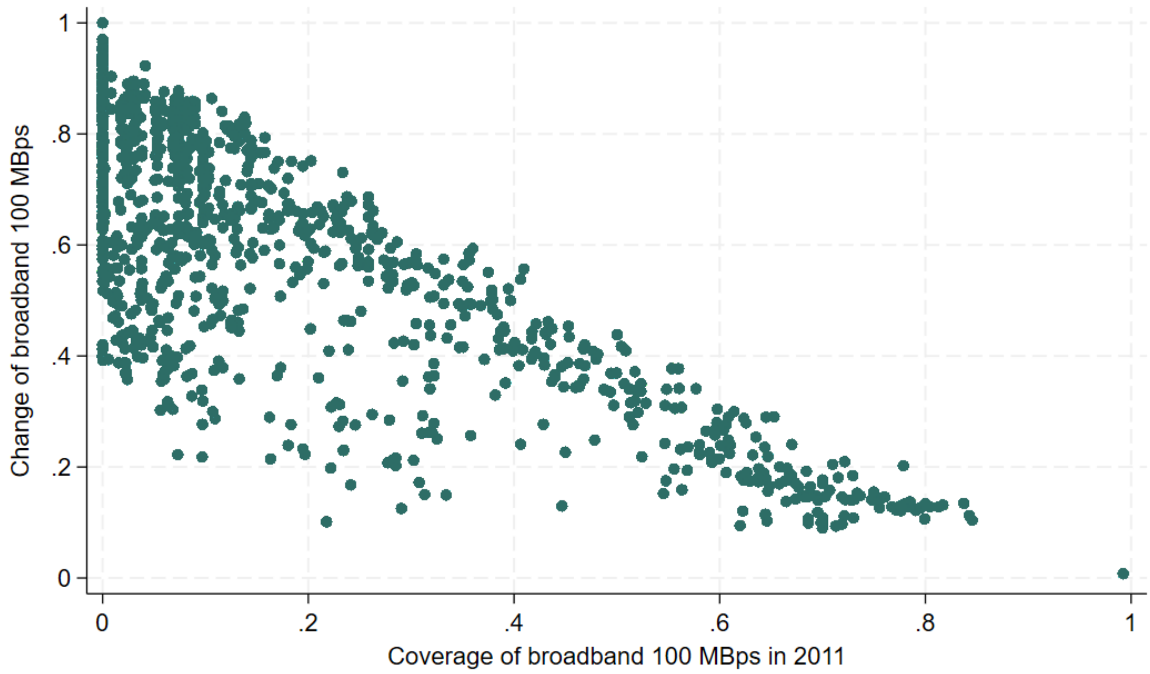


Figure 5: Broadband convergence (100 Mbps), EU NUTS3 regions

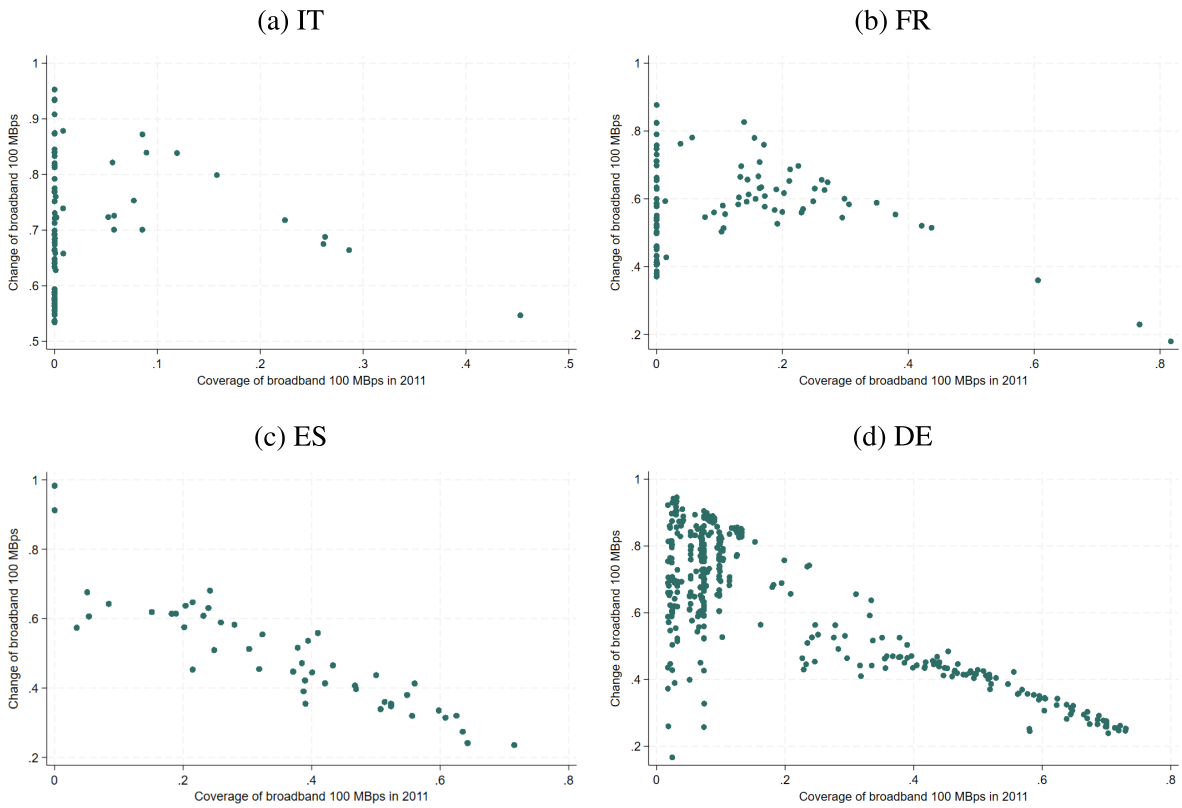


Figure 6: Selected countries. Broadband convergence (100 Mbps), NUTS3 regions

2.3 Industry concentration measures

Given the definition of market share of firm i, in year t, in country c and in industry s:

$$MS_{i,t}^{s,c} = \frac{sales_{i,t}^{s,c}}{\sum_{i=1}^{N_t^{s,c}} sales_{i,t}^{s,c}} \tag{1}$$

where $N_t^{s,c}$ identifies the 50 largest firms for any given sector, country and time, we calculate two standard measures of market concentration:

i) The concentration ratio (CR_q), which expresses the (MS) of the q largest firms in a market:

$$CR_{q,t}^{s,c} = \sum_{i=1}^{q} MS_{i,t}^{s,c} \tag{2}$$

We focus on the combined market shares of the four largest firms, $q = 4$.[4]

ii) The standard *Herfindahl-Hirschman* index :

$$HHI_t^{s,c} = \sum_{i \in s,c}^{N_t^{s,c}} \left(MS_{i,t}^{s,c}\right)^2 \tag{3}$$

3 Markup estimates

The theoretical framework follows Loecker and Warzynski (2012). Consider an economy where N heterogeneous firms operate under Cournot competition. A multiple-input production function characterises firm i is :

$$Y_{i,t} = F_{i,t}\left(L_{i,t}, K_{i,t}, M_{i,t}, \Theta_{i,t}\right) \tag{4}$$

where $L_{i,t}, K_{i,t}, M_{i,t}$, respectively, define labour, capital, and intermediate inputs, and $\Theta_{i,t}$ is the Hicks-neutral productivity shifter. Intermediate inputs have their price $P_{i,t}^{\Theta}$. Finally, both capital and the output goods are associated with a price ($R_{i,t}$ for the former and $P_{i,t}$ for the latter). From the cost-minimisation problem of the firms, we obtain labour demand:

$$\theta_{i,t}^L = \frac{1}{\lambda_{i,t}} \frac{w_{i,t} L_{i,t}}{Y_{i,t}} \tag{5}$$

where $w_{i,t}$ is the wage, and $\theta_{i,t}^L = \frac{\partial F_{i,t}(L_{i,t}, K_{i,t}, \omega_{i,t})}{\partial L_{i,t}} \frac{L_{i,t}}{Y_{i,t}}$ is the labour elasticity of output. Bearing in mind that the Lagrangean multiplier $\lambda_{i,t}$ is equal to the marginal cost, the markup definition obtains:

$$\mu_{i,t} \equiv \frac{P_{i,t}}{\lambda_{i,t}} = \frac{\theta_{i,t}^L}{\alpha_{i,t}^L} \tag{6}$$

[4] According to Kalemli-Özcan et al. (2024), the dynamics of the concentration index do not change if one looks at the eight largest firms.

where $P_{i,t}$ defines the firm's good price and $\alpha_{i,t}^L = \frac{w_{i,t}L_{i,t}}{P_{i,t}Y_{i,t}}$ is the labour share. As shown in Loecker and Warzynski (2012), by modelling the firm-specific (unobserved) productivity process, markups can be estimated even if the user cost of capital cannot be observed, and it is not necessary to impose constant returns to scale.

Estimates of $\mu_{i,t}$ are obtained as follows. Following Ackerberg et al. (2015), we assume the following value-added translog production function in log capital $k_{i,t}$ and log labour input $l_{i,t}$:

$$y_{i,t} = \beta_l l_{i,t} + \beta_k k_{i,t} + \beta_{ll} l_{i,t}^2 + \beta_{kk} k_{i,t}^2 + \beta_{lk} l_{i,t} k_{i,t} + ln\Theta_{i,t} \tag{7}$$

where $y_{i,t}$ defines the firm's added value in logs and

$$ln\Theta_{i,t} = \omega_{i,t} + \varepsilon_{i,t} \tag{8}$$

is a combination of a productivity shifter that follows a first-order Markov process, $\omega_{i,t}$, and a residual $\varepsilon_{i,t}$. As discussed in Rovigatti and Mollisi (2018), the log of intermediate inputs, $m_{i,t}$, can be exploited to net out the unobservable term $\omega_{i,t}$, and $l_{i,t-1}$ must then be used as an instrument to control for the simultaneity bias associated with the dynamic process that drives $\omega_{i,t}$.[5] One important "practical" detail concerning this popular method for obtaining markup estimates using firms' balance sheet data is that real output is typically unavailable and replaced with the revenues/sales variable. Bond et al. (2021) show that revenue-based estimates are biased relative to estimates obtained when quantities are directly observable. The intuition underlying this result is that the revenue-based elasticity correctly identifies the true elasticity only to the extent that the firm is a price taker; however, markups above one require that firms exploit market power to set their prices. De Ridder et al. (2024) reconsider the issue and reach more optimistic conclusions. Their theoretical model shows that variation in markups across firms or over time can still be accurately measured if firms have output elasticities that are sufficiently close. Revenue-based markup estimates still correlate with the true markups even when output elasticities differ. This claim is empirically validated using a French dataset of manufacturing firms. Of particular interest to our work is their conclusion that both the dynamics and the dispersion of markups across firms can still be accurately measured using revenue data. This is because we are not concerned with a descriptive analysis of markups, but rather with their responses to broadband shocks. Figure 7 displays the distribution of markup estimates for a selection of industries. The figure shows a great deal of heterogeneity across sectors. Figure 8 reports the distribution across countries. In this case, the difference reflects the different sectoral composition of the sample.

[5] Markup estimates have been obtained using the STATA routine markupest, whose features are discussed in Rovigatti (2020). Values for Markup estimates have been trimmed at 1 and 99%

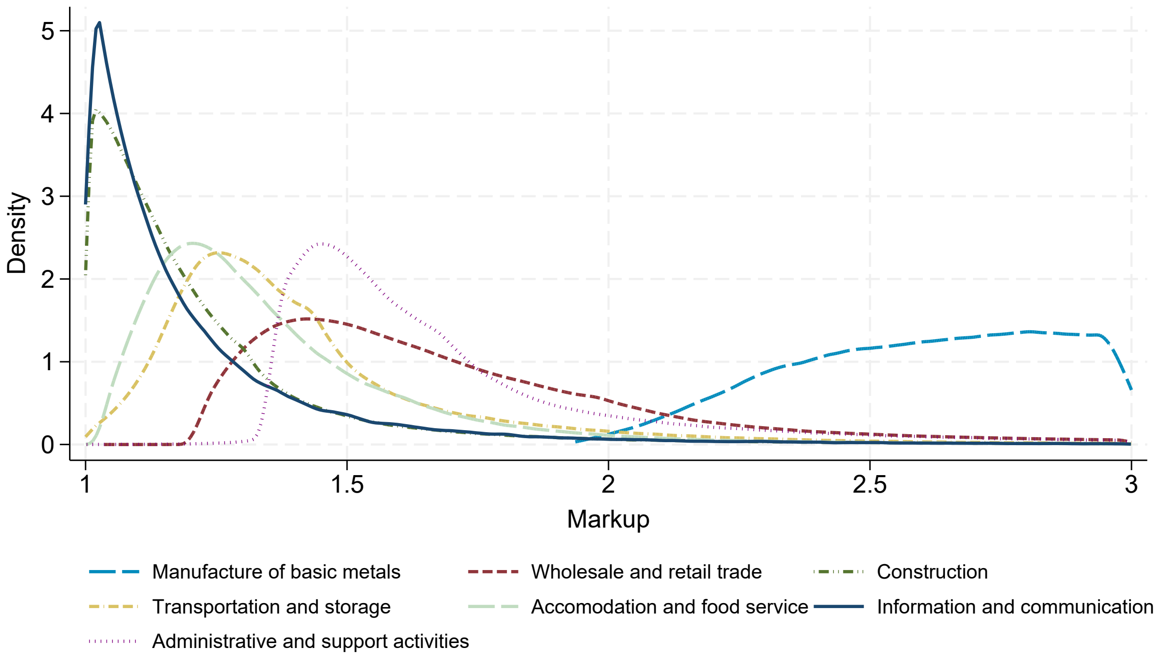


Figure 7: Markup distribution for selected industries

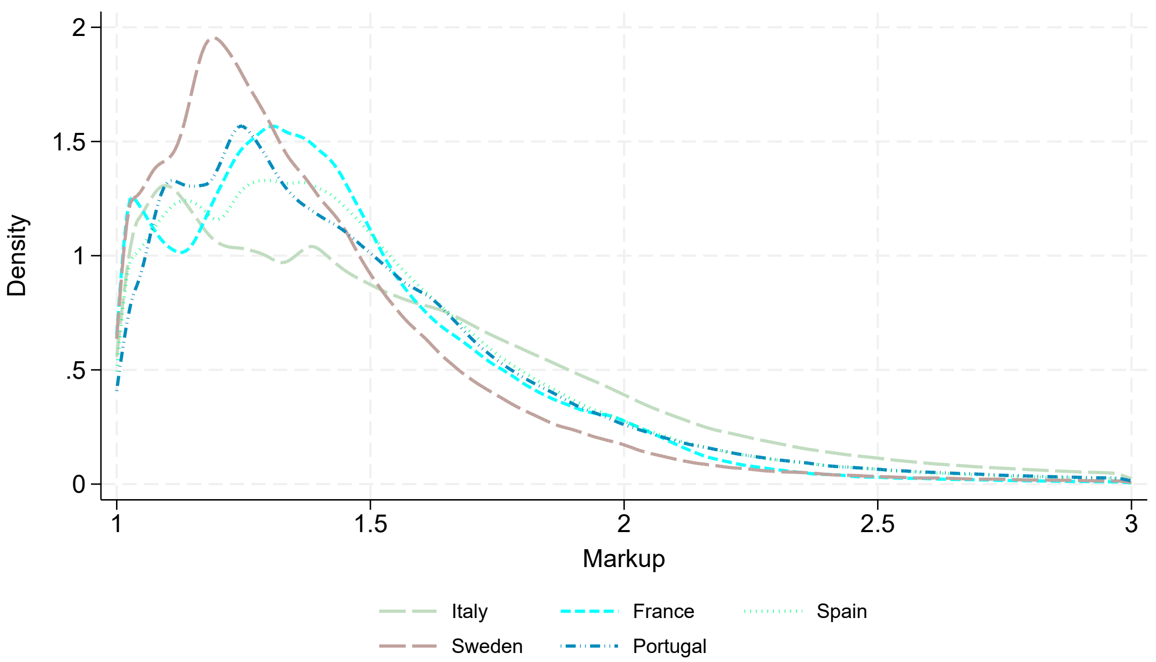


Figure 8: Markup distribution for selected countries

3.1 Estimated markups and the identification of fixed costs

Following (De Ridder, 2024b), firm-level fixed costs can be identified from balance-sheet data on operating profits and revenues, and from the estimated markups. More specifically, fixed costs, $f_{(i,t)}$, are given by

$$f_{(i,t)} = \left(1 - \frac{1}{\mu_{(i,t)}}\right) S^*_{(i,t)} - \Pi_{(i,t)} \tag{9}$$

where $\frac{1}{\mu_{(i,t)}}$ is the marginal cost, $S^*_{(i,t)}$ are firm revenues, and $\Pi_{(i,t)}$ are the firm's operating profits. Therefore, recovering fixed costs measures is straightforward once the individual firms' markups have been estimated.

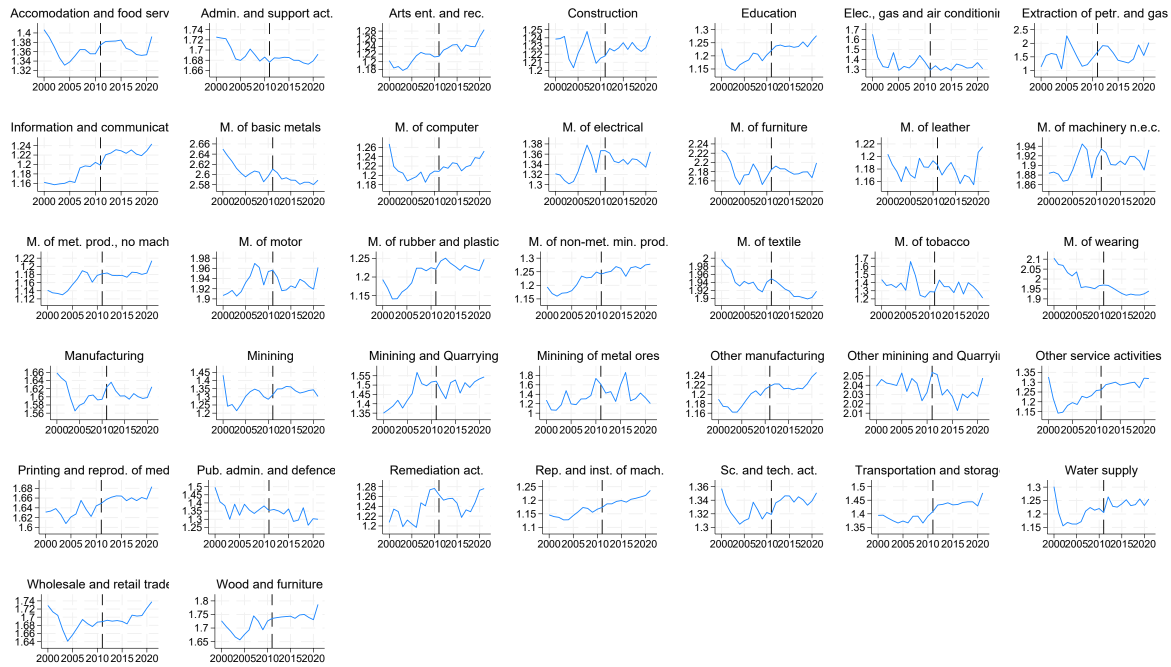


Figure 9: Markups trends - different sectors

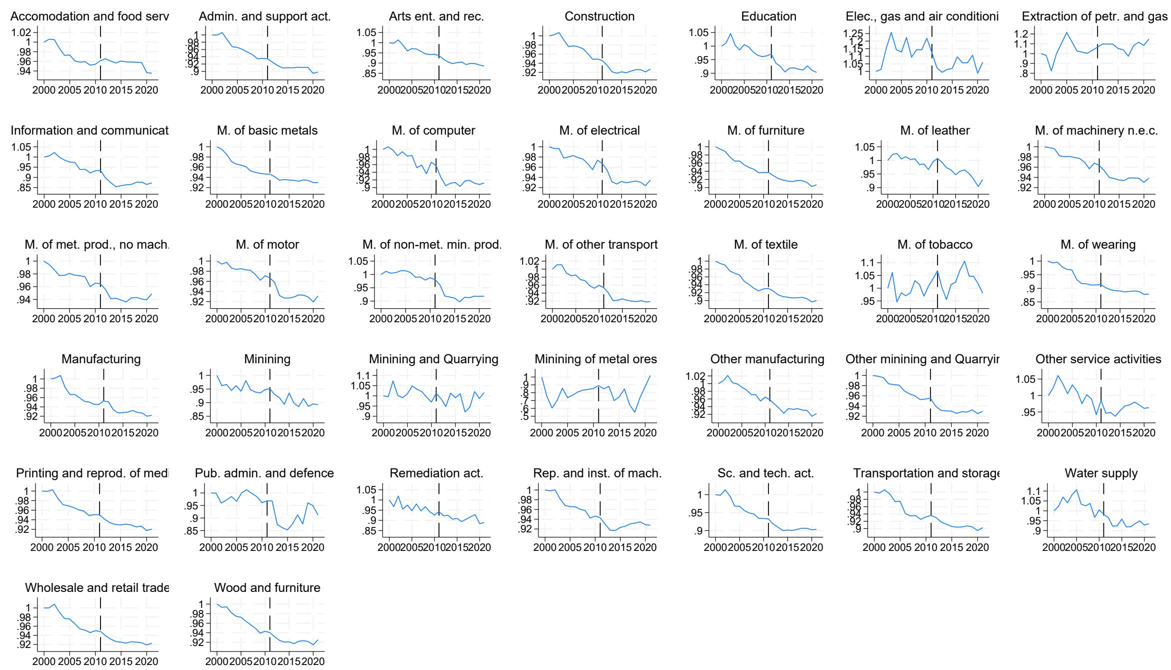


Figure 10: Fixed cost trends, different sectors - 2000 base year

4 Estimating the effects of broadband connectivity

Estimates of broadband effects are subject to concerns about endogeneity. For instance, local economic shocks may simultaneously impact the decision to roll out broadband coverage in a territorial unit and the profitability (or markups) of local firms.

In principle, previous studies that investigate the effects of broadband connectivity on firms' total factor productivity (TFP) could provide helpful insights. The broadband connectivity variable could be instrumented with a measure of geographical broadband availability, which typically raises the cost of broadband deployment, as in Kolko (2012), Czernich et al. (2011), Haller and Lyons (2015) and Cambini et al. (2023). These measures are particularly useful when the geographical size of the territorial unit is small, such as at the municipal level. However, it is difficult to obtain such measures covering the large area considered in this study, and aggregating municipality data at the NUTS3 level would pose some potentially formidable obstacles. Furthermore, geographical distance indicators are fixed effects, making it difficult to exploit them to capture the dynamic impact of broadband coverage over a relatively long period.

Our choice is to extract broadband shocks residually from the following dynamic model.

$$BB_{j,c,r,t} = \beta_0 + \beta_1 BB_{j,r,t-1} + \beta_2 Popdens_{r,t} + \beta_3 GDPpc_{r,t} + \beta_4 TFPG_{r,t} + \gamma_t + \alpha_r + \alpha_c + \epsilon_{j,c,r,t} \tag{10}$$

where BB defines broadband coverage, j,c,r,t respectively define the speed of connectivity, the country, the region, and time; $Popdens$, $GDPpc$ and $TFPG$ denote population density, GDP per capita in PPP standards, and regional TFP growth recovered from our estimates of firms' TFP growth.[6] Finally, α_t, α_r, and α_c denote time, regional, and country fixed effects, respectively.[7] From the estimates of 10, we recover the broadband forecast error, ϵ^{BB}, which defines our broadband shock series.[8]

We estimate impulse responses using the following local projections at annual frequency (see Jordà and Taylor (2025); Jordà (2005)).

$$\sum_{j=0}^{h} \Delta\chi_{i,s,c,r,t+h} = \alpha_h + \beta_h \sum_{j=0}^{h} \epsilon^{BB}_{j,c,r,t} + \Gamma_h X_{i,s,c,r,t} + D_{i,r,s,c,t} + \upsilon_{i,s,c,r,t+h} \tag{11}$$

where $\Delta\chi$ defines firm i's variable of interest: markups, fixed costs, sales, and operating profits. X is a vector of controls, including one of our sectoral concentration measures,

[6] TFP estimates are obtained following Rovigatti (2020), and are entirely consistent with our firm markup estimates.

[7] $BB_{j,r,t-1}$ is intended to eliminate predictable patterns of broadband coverage expansion, whereas endogeneity concerns motivate the inclusion of the other controls.

[8] Table 3 and Figure 18 provide some descriptive statistics for the broadband shock series and plot the distribution of ϵ^{BB}.

CR and HHI, one lagged value of ϵ^{BB} and some firm-specific controls evaluated at time t: leverage ($(long\ term\ debt + loans)/total\ assets$), size ($\log(1 + number\ of\ employees)$) and profitability ($ebitda/total\ assets$).[9] The regression is saturated by firm, region, sector, country, and year dummies, plus sector times year dummies, all of which are included in the vector $D_{i,r,s,c,t}$. Finally, $\upsilon_{i,s,c,r,t+h}$ denotes the error term.[10]

5 Results

Our results measure how (fast)broadband shocks affect each variable of interest over up to four years. We report impulse responses to a one-standard-deviation broadband coverage shock at an annual frequency, based on the local projection approach described in equations (11) and (12).[11]

Figure 11 shows that the markups' cumulative response to both 30 Mbps and 100 Mbps shocks is positive. However, the latter effect is smaller and less precisely estimated. The difference in outcomes between 30 Mbps and 100 Mbps could be due to the varying timelines for deploying 30 Mbps and 100 Mbps broadband across Europe. While 30 Mbps connections were implemented in most areas early in our sample period, the expansion of 100 Mbps broadband occurred primarily toward the end of the timeframe under study. This lag in deployment limits our ability to fully assess the potential benefits of high-speed broadband adoption. Consequently, the remainder of the paper will focus on the findings related to 30 Mbps broadband, with the figures for 100 Mbps included in the Appendix.[12]

As stressed in the introduction, technological change (e.g. broadband diffusion) can raise markups by increasing market concentration and/or raising fixed or sunk costs, which in turn require higher markups to be recovered. Our estimates signal an increase of markups even after controlling for market concentration. The next step therefore is to focus on the evolution of fixed costs. One distinct feature of our analysis is that wel shall also look at the responses of sales and profits to the broadband shock.

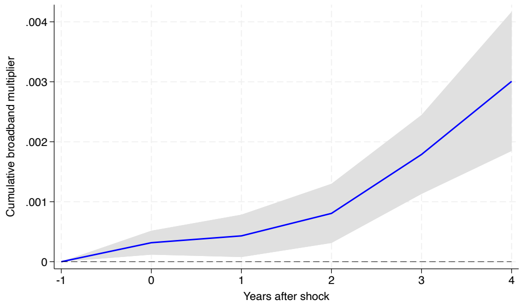
Figure 12 shows the responses of fixed costs, sales, and profits, documenting a significant increase for these variables, approximately one order of magnitude larger than the estimated response of markups. Therefore, the broadband shock is unambiguously expansionary, as evidenced by the increases in both sales and profits. Even if fixed costs do increase in response to the shock, we cannot conclude what caused the markup increase: it is still possible that

[9] The lag structure has been chosen using the Bayesian Information Criterion (BIC), as shown in table 2. Section 5.2 shows that results are robust to different lag structures.

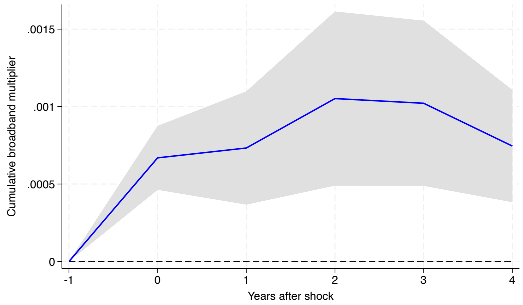
[10] As pointed out in Jordà and Taylor (2025), in Local Projection estimates, potential correlation across individual units is a source of concern, in addition to the moving-average structure of the residuals in the time-series dimension. Researchers often compute Driscoll-Kraay robust standard errors (Driscoll and Kraay (1998)). This method is particularly appropriate when the T dimension of the dataset is relatively large. In our dataset, T is rather short and N is very large. We therefore opted for clustering errors at the NUTS3 level.

[11] All figures show 95 percent confidence bands.

[12] Table 4 in the appendix reports the entire regression results of figure 11a.



(a) Broadband (30 Mbps)



(b) Fast broadband (100 Mbps)

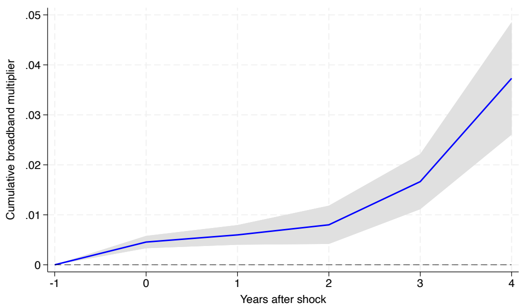
Figure 11: Markup responses to BB shocks

The figure shows the cumulative impulse response functions and the associated 95 percent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (11). Values refer to a one standard deviation in Broadband shock.

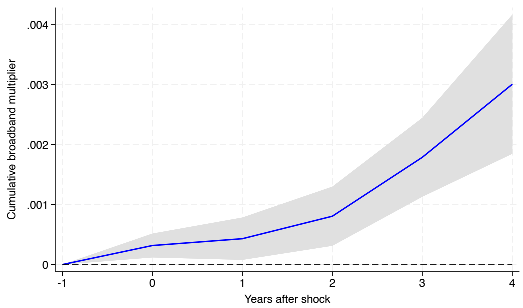
firms' profit margins exceed what is required to cover the increase in fixed costs.

To clarify this argument we therefore decided to: i) normalise fixed costs and profitability by the amount of sales, to enable a direct quantitative comparison between the response of these variables, per unit of sold output, and the one observed for markups; 2) estimate three versions of equation (11), alternating markups, fixed costs-to-sales, and profitability-to-sales as the dependent variable, and including the lagged values of the other two in the control vector X. By doing this, we account for the cross-relations between markup, fixed costs, and profits.

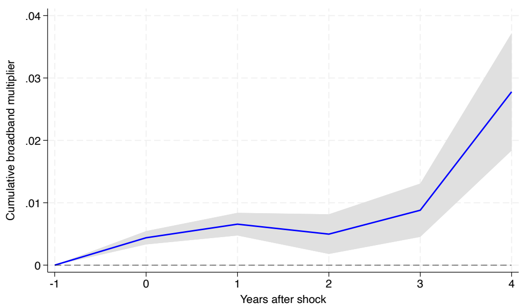
The results, presented in Figure 13, are striking. In addition to the increase in markups we have already observed, the profits-to-sales ratio increases significantly, but the fixed-costs-to-sales ratio exhibits a nearly muted response. Therefore, even if the fixed costs tend to rise, as documented in Figure 12, it turns out that firms manage to increase their markups and still expand sales in a way that stabilises fixed costs per unit of revenue. As a result, profits per unit of revenue also increase.



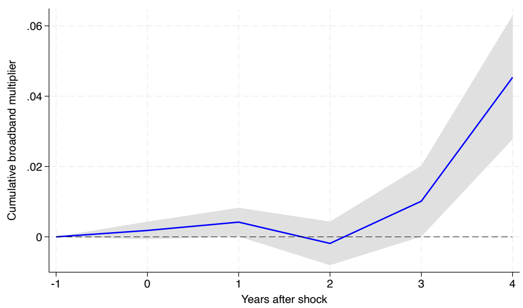
(a) Effect on fixed cost



(b) Effect on markup



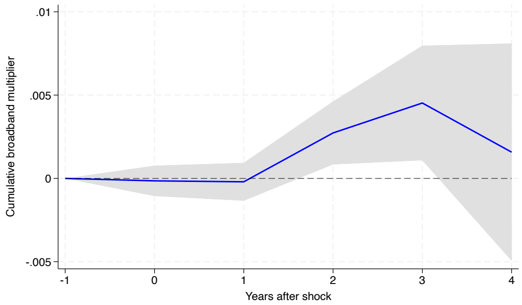
(c) Effect on sales



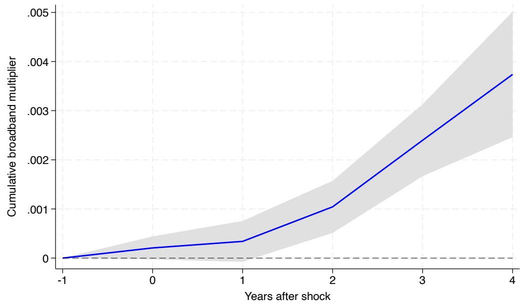
(d) Effect on profits

Figure 12: IRFs to a broadband shock (30 Mbps)

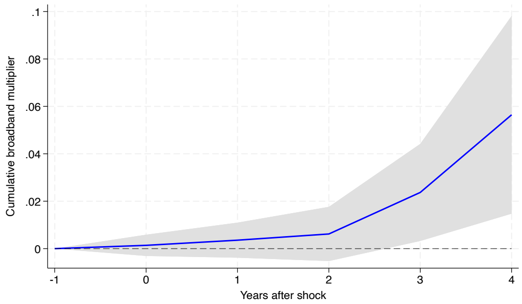
The figure shows the cumulative impulse response functions and the associated 95 per cent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (11). Values refer to a one standard deviation in Broadband shock.



(a) Broadband effect: fixed costs-to-sales ratio



(b) Broadband effect: markup



(c) Broadband effect: profits-to-sales ratio

Figure 13: NEW Broadband (30 Mbps): accounting for interdependencies

The figure shows the cumulative impulse response functions and the associated 95 per cent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (11). Values refer to a one standard deviation in Broadband shock.

5.1 Conditional effects

One appealing feature of local projections is that they can easily accommodate non-linearities in the effects of broadband shocks, by incorporating smooth transition functions to analyse how the impact of a shock varies across different economic conditions or states (see Auerbach and Gorodnichenko (2013). Tenreyro and Thwaites (2016), Colombo et al. (2024)). More specifically, smooth transitions are estimated as follows:

$$\sum_{j=0}^{h} \Delta\chi_{i,s,c,r,t+h} = \alpha_h + F(z_i)\beta_h^L \sum_{j=0}^{h} \epsilon_{j,c,r,t}^{BB} + (1 - F(z_i))\beta_h^H \sum_{j=0}^{h} \epsilon_{j,c,r,t}^{BB} + \\ + \Gamma_h X_{i,s,c,r,t} + D_{i,r,s,c,t} + \upsilon_{i,s,c,r,t+h} \quad (12)$$

where β_h^L and β_h^L respectively characterise the estimated effects of the (fast)broadband shocks for the lower(upper) tail of the distribution of Z, $z_i = \frac{Z_i - Z^{AV}}{\text{SD}(Z)}$ defines the normalised deviation of Z_i from its average value and $F(z_i) = \frac{\exp(-\gamma z_i)}{1+\exp(-\gamma z_i)}$.[13] $F(z_i)$ can be interpreted as the probability that firm *i* is associated with $z \leq z_i$. The parameter γ controls the speed of transition between β_h^L and β_h^L.[14]

[13]Note that z_i is normalized to have zero mean and a unit variance. To reduce endogeneity, due to the potential response of Z to broadband shocks, we consider the average size of Z_i over the sample period

[14]We set $\gamma = 5$, we can show that the results are robust to alternative values (results available upon request).

Interacting the broadband shock with certain features of the firms' distribution yields intriguing results. Our analysis unfolds in two steps. In the first one, we reconsider the results presented in Figure 12, concerning the IRFs of markups, sales fixed costs, and profits. In the second, we look at the effects on markups and the ratio of fixed costs and profits to sales.

Figures 14 and 15 show that firms characterized by high-TFP levels, large sales, and high fixed costs are also characterized by stronger responses of markups, fixed costs, and profits. If we look at the opposite tail of the firms' distribution, it is easy to see that the markups of small firms do not increase in response to the broadband shock. Furthermore, firms characterised by low TFP and by low fixed costs exhibit a reduction in their markups, and fixed costs exhibit a statistically significant reduction. Fixed costs tend to increase for firms at the lower tail of the distributions for sales and fixed costs, whereas there is no significant variation for low-TFP firms.

Let us now turn to step 2, results are reported in Figure 16. To begin with, we focus on the responses of markups and fixed-cost ratios. High fixed costs and high TFP firms see an increase in both the fixed-cost-to-sales ratio and in the markup, with the response of the former variable being stronger. By contrast, firms at the opposite tail of the distribution (both TFP and fixed-cost ratio) exhibit a tendency to reduce markups and a muted response of fixed-cost ratios. Profit-to-sales ratios tend to increase more for high-sales, high-TFP, and high-fixed-cost firms.

These results suggest a re-interpretation of our unconditional estimates, which apparently hide important changes in the relative position of firms in consequence of the shock. The three characteristics highlighted in our smooth transitions estimates, i.e. the relative position of firms in terms of size, TFP and fixed costs, convey a coherent message: firms at the right tail of the distributions adopt strategies that raise fixed costs per unit of revenue and markups, where the adjustment of the latter tends to be weaker. Eventually, this increases their profitability, but only after 4 years. By contrast, firms at the opposite tail apparently tend to adopt strategies that are more conservative in terms of fixed costs and markups, penalising their profitability.

Borrowing from (Aghion et al. (2023)), one might argue that internet broadband shocks lower the fixed costs that firms must incur to enter a new market. Firms who adopt this strategy manage to increase markups and profitability, but they must raise their expenditures in fixed costs. Our empirical analysis allows us to pinpoint which firms are more (less) likely to make this choice. According to Aghion et al. (2023), it is the most efficient firms (with higher markups) that enter these new markets and increase concentration. Bearing in mind that our results are obtained controlling for market concentration, we uncover distinct roles for firms that are large, have large fixed costs, and are more efficient (have high TFP levels).

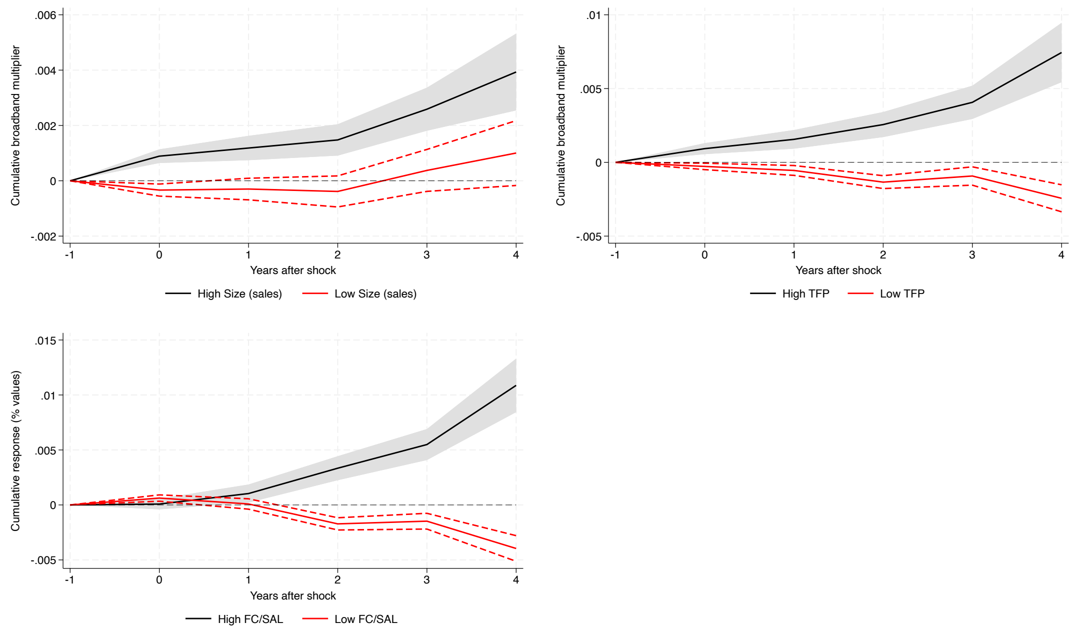


Figure 14: Markup responses to a broadband (30 Mbps) shock: firm-specific effects

The figure shows the cumulative impulse response functions and the associated 95 percent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (12). Panels display smooth transition functions constructed on the reported variables. Values refer to a one standard deviation in Broadband shock.

5.2 Robustness

We conducted a series of robustness checks to validate our results. First, we examined the impact of alternative lag structures for the broadband shock. As shown in Figure 17, specifications using two and three lags yield results that closely resemble the baseline model with three lags. Second, we excluded the period affected by the COVID-19 pandemic, which may have influenced economic performance toward the end of the sample period. As illustrated in panel (c), this exclusion does not alter the main findings. Finally, given that local projections (LP) are estimated over varying time horizons, longer horizons naturally result in smaller samples due to the unbalanced nature of the panel. To ensure that changes in sample composition do not drive our results, we re-estimated the model on a balanced sample of firms that survive through the longest horizon. As shown in panel (d), the findings remain robust.

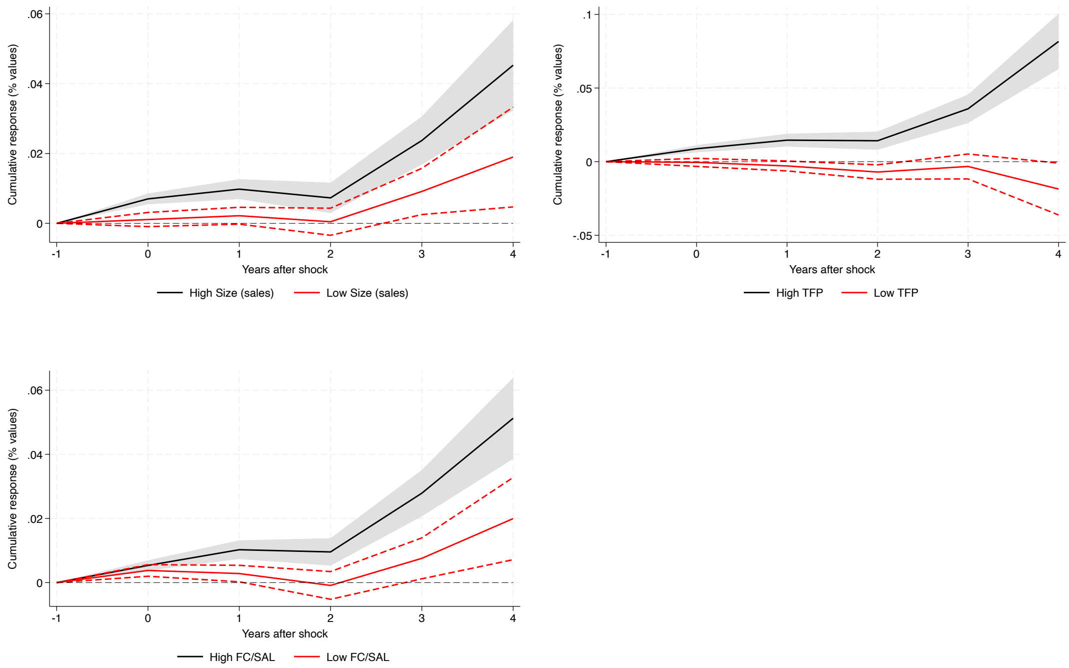
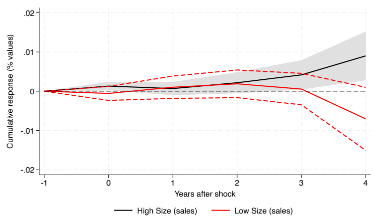
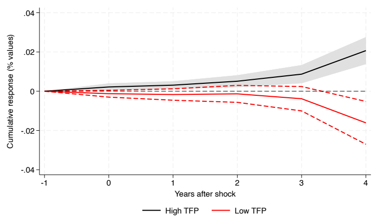


Figure 15: Fixed costs responses to a broadband (30 Mbps) shock: firm-specific effects

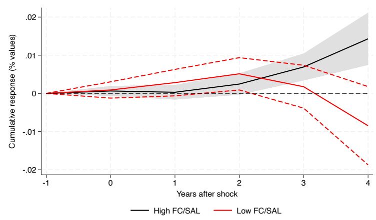
The figure shows the cumulative impulse response functions and the associated 95 percent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (12). Panels display smooth transition functions constructed on the reported variables. Values refer to a one standard deviation in Broadband shock.



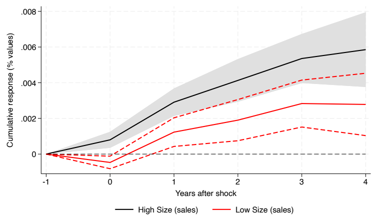
(a) Fixed costs/sales : sales



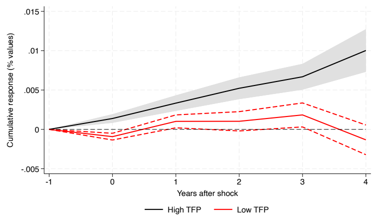
(b) Fixed costs/sales: TFP



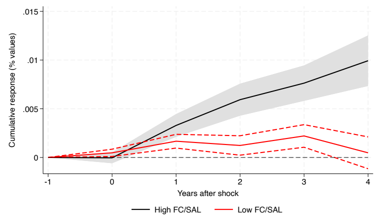
(c) Fixed costs/sales: fixed costs



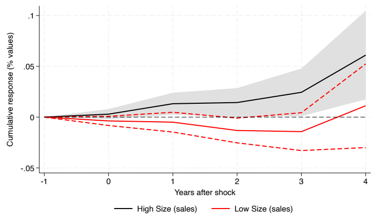
(d) Markup: sales



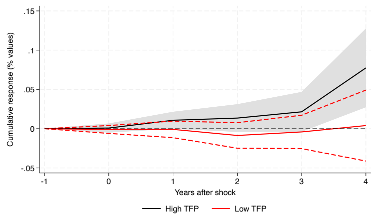
(e) Markup: TFP



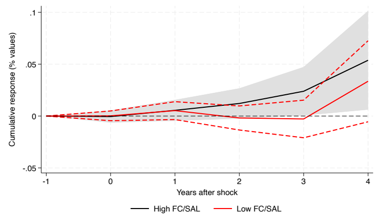
(f) Markup: fixed costs



(g) Profits/sales : sales



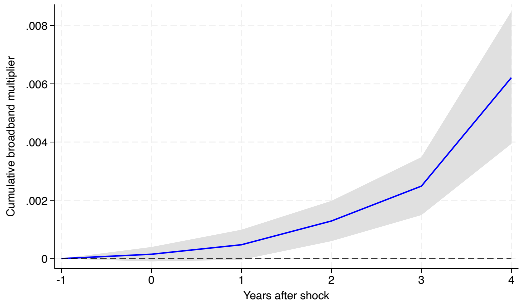
(h) Profits/sales: TFP



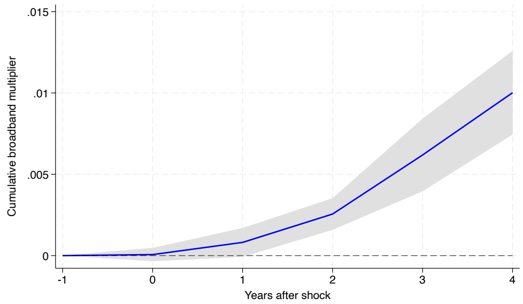
(i) Profits/sales: fixed costs

Figure 16: Responses to a broadband (30 Mbps) shock: firm-specific effects

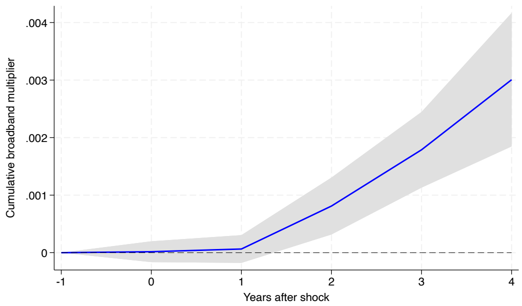
The figure shows the cumulative impulse response functions and the associated 95 percent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (12). Panels display smooth transition functions constructed on the reported variables. Values refer to a one standard deviation in Broadband shock.



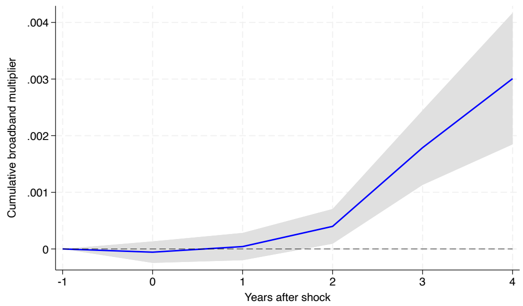
(a) BB 30: 2 Lags



(b) BB 30: 3 Lags



(c) BB 30: excluding the Covid-19 period



(d) BB 30: constant sample

Figure 17: Bbroadband (30 Mbps): robustness checks

The figure shows the cumulative impulse response functions and the associated 95 percent confidence bands; $t = 0$ is the year of shock. The shock is constructed using equation (10). Estimates follow equation (11). Values refer to a one standard deviation in Broadband shock.

6 Conclusions

The paper investigated the firms' responses to broadband shocks, exploiting a large dataset based on balance sheets of European firms.. This was done by applying the local projections method, also using smooth transition estimates to condition our shocks on firm-specific features.

By doing this, we can address important questions concerning the polarisation of firms' distribution. Does the distinction between high-tech and laggard firms contribute to explaining the estimated markup responses to broadband shocks?

On average, broadband shocks raise sales, profits-to-sales ratios, and markups. By contrast, fixed cost-to-sales ratios, on average, remain broadly constant even if fixed costs do increase. The shock therefore is expansionary, and firms exploit it to raise profit margins and profitability. The interactions between the shock and certain firm features (TFP level, fixed-cost-to-sales ratio and sales) show important differences across firms at the tails of the firms' distributions, pointing at the polarising effects of broadband shocks.

These results suggest that the fixed costs adjustment should be treated as part of the firms' profit-maximizing strategy in response to the shock. In fact, by simply looking at unconditional estimates one misses the important comovement between the increase in fixed costs and markups for firms that are eventually able to raise their profitability. Last, but not least, we are able to identify the firms' features that are more likely to choose this strategy.

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Appendix

Table 1: Descriptive statistics

Variable	Mean	Std. Dev.	Min.	Max.	N	Source
BB 30 Mbps (%)	0.746	0.239	0	1	5039212	Point Topic
BB 100 Mbps (%)	0.594	0.321	0	1	5039212	Point Topic
Leverage	0.158	0.188	0	1	5039212	Orbis
Employment (log)	2.188	0.991	0	9.445	5039212	Orbis
Profitability	14.399	20.912	-627.775	26093.031	5039212	Orbis
Sales (log)	13.439	1.427	6.88	21.572	5039212	Orbis
TFP	8.476	1.67	-109.652	62.937	5037328	Orbis
digital_intensity	2.391	1.069	1	4	5039212	OECD
HHI	0.022	0.009	0.02	1	5039212	Orbis
Markup	1.423	0.48	0.407	4.258	5039212	Orbis
Markup growth	0.007	0.091	-0.812	1.998	5039212	Orbis
GDP pc PPS*	26.57	12.49	4.1	177.6	20045	Eurostat
Population Density*	401.81	990.06	1.796	21877.38	13489	Eurostat

* denote variables observed at Nuts3 level

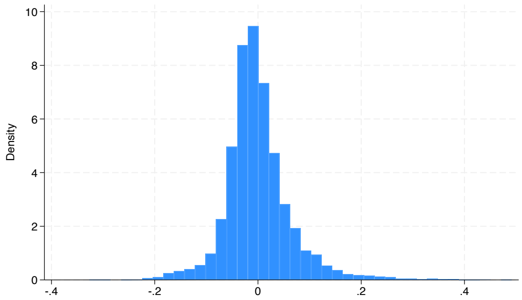
Table 2: Lag Length Selection Using Information Criteria.

N. Lags	$k = 0$	$k = 1$	$k = 2$	$k = 3$	$k = 4$
1	-9475346.2	-6902919.4	-5349218.8	-4266810.4	-3361570.9
2	-8784646.9	-6361,662.6	-4916130.4	-3869576.8	-2967671.3
3	-7880078.4	-5666936.4	-4323323.0	-3308435.5	-2356532.3

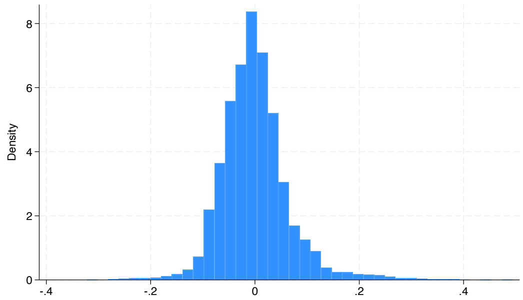
Note: The table shows the value of the Bayesian Information Criterion (BIC), for different lag structures and for each horizon k. The lag order that minimizes BIC for all horizons is 1.

Table 3: Descriptive statistics BB shock

Variable	Mean	Std. Dev.	Min.	Max.	N
ϵ BB30	0	0.065	-0.326	0.718	10242
ϵ BB100	0	0.065	-0.323	0.494	10242



(a) BB 30 Mpbs



(b) BB 100 Mpbs

Figure 18: Distribution of Broadband shock

The figure shows the distribution of ϵ^{BB} calculated as a residual from equation (10). Table 3 reports descriptive statistics.

Table 4: Effects of broadband shock

	h=0	h=1	h=2	h=3	h=4
ϵ^{BB}	0.0003**	0.0004*	0.0008**	0.0018***	0.0030***
	(0.0001)	(0.0002)	(0.0003)	(0.0003)	(0.0006)
L.ϵ^{BB}	-0.0003*	-0.0006**	0.0001	0.0014***	0.0015***
	(0.0001)	(0.0002)	(0.0002)	(0.0003)	(0.0002)
L.MKUP	-0.3990***	-0.5157***	-0.5719***	-0.6008***	-0.6111***
	(0.0034)	(0.0033)	(0.0029)	(0.0025)	(0.0025)
L2.MKUP	-0.2157***	-0.2880***	-0.3267***	-0.3451***	-0.3426***
	(0.0019)	(0.0019)	(0.0019)	(0.0024)	(0.0029)
Leverage	0.0004	0.0270***	0.0233***	0.0111***	-0.0003
	(0.0018)	(0.0018)	(0.0017)	(0.0016)	(0.0015)
Size	-0.0379***	-0.0318***	-0.0163***	-0.0097***	-0.0089***
	(0.0018)	(0.0012)	(0.0006)	(0.0006)	(0.0006)
Profitability	0.0002	-0.0000	-0.0002***	-0.0001***	-0.0001***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
HHI	-0.0185	-0.0309	-0.0007	0.0057	-0.0010
	(0.0110)	(0.0162)	(0.0144)	(0.0182)	(0.0193)
Constant	0.0894***	0.0784***	0.0478***	0.0364***	0.0393***
	(0.0045)	(0.0027)	(0.0014)	(0.0015)	(0.0014)
R2	.3070602897	.4497132318	.5496415419	.6445311342	.7248209277
N	3,868,714	2,960,727	2,250,540	1,706,024	1,262,297

Note: the table shows regression coefficients of the cumulative multiplier based on equation (11). Dependent variable is Markup growth. h defines the time horizon of the IRF. All regression include firm, sector, region (NUTS3), country and time fixed effects as well as sector×time effects. Robust standard errors clustered at NUTS3 level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Industry	Frequency	Percent	Mean	
			HHI index	CR4 index
Accomodation and food service activities	908,859	8.23	.0211661	.0414706
Administrative and support activities	588,064	5.33	.021406	.0399896
Arts entertainment and recreation	80,907	0.73	.021908	.0321542
Construction	1,423,751	12.90	.0207665	.0519172
Education	33,460	0.30	.022137	.0301091
Electricity, gas, steam and air conditioning supply	754	0.01	.0247215	.0185307
Extraction of crude petroleum and natural gas	13	0.00	.6904203	.5502633
Information and communication	168,103	1.52	.0212779	.0419604
Manufacture of basic metals	16,089	0.15	.0236895	.0257418
Manufacture of basic pharmaceutical products and pharmaceutical preparations	15	0.00	.0618825	.0112102
Manufacture of beverages	180	0.00	.0233496	.0255174
Manufacture of chemicals and chemicals products	63	0.00	.0229518	.0267157
Manufacture of coke and refined petroleum products	2,240	0.02	.105697	.0341077
Manufacture of computer, electronics and optical products	12,587	0.11	.0225614	.0281153
Manufacture of electrical equipment	66,790	0.61	.0221484	.0303836
Manufacture of fabricated metal products, except machinery and equipment	427,155	3.87	.0213668	.0384772
Manufacture of furniture	104,683	0.95	.0223074	.0264413
Manufacture of leather and related products	7,728	0.07	.0225132	.0271604
Manufacture of machinery and equipment n.e.c.	197,651	1.79	.0218478	.0332129
Manufacture of motor vehicles, trailers and semi-trailer	33,142	0.30	.0248354	.0246022
Manufacture of other non-metallic mineral products	24,897	0.23	.0221008	.0299099
Manufacture of other transport equipment	20,272	0.18	.0306599	.0237572
Manufacture of paper and paper products	4,231	0.04	.0231821	.0243863
Manufacture of rubber and plastic products	59,300	0.54	.0223276	.0267017
Manufacture of textile	77,423	0.70	.0224026	.0270506
Manufacture of tobacco products	89	0.00	.5392399	.3806743
Manufacture of wearing apparel	102,504	0.93	.0227584	.0249981
Manufacturing	283,561	2.57	.0217523	.0329047
Minining and Quarrying	237	0.00	.4833817	.3740338
Minining of metal ores	44	0.00	.4317513	.1851153
Minining support and service activities	1,385	0.01	.1705966	.0477749
Other manufacturing	50,893	0.46	.0221639	.0300622
Other minining and Quarrying	31,635	0.29	.0240506	.0228572
Other service activities	12,939	0.12	.0220076	.0309878
Printing and reproduction of of recorded media	116,784	1.06	.0216605	.0346051
Professional, scientific and technical activities	1,465,442	13.28	.0213588	.042314
Public administration and defence: compulsory social securety	1,402	0.01	.1083141	.0138128
Remediation activities and other waste management services	2,105	0.02	.0357322	.0176385
Repair and installation of machinery equipment	122,657	1.11	.022057	.030385
Transportation and storage	879,184	7.96	.0214975	.0383797
Water supply: sewerage, waste management and remediation activities	4,306	0.04	.022904	.0266658
Wholesale and retail trade; repair of motor vehicles and motorcycles	3,573,051	32.37	.0207049	.0536345
Wood and furniture	132,300	1.20	.0223417	.0283707
Total	11,038,875	100.00	.0212695	.0447796

Table 5: HHI and CR4 index average 2011-2022

Dataset construction

We build our dataset exploiting Orbis Historical provided by Bureau Van Dijk. We follow the approach of Kalemli-Özcan et al. (2024) and **?** for data cleaning. We therefore focus on non-financial corporations, accounting for variations in sector-level characteristics such as dependence on external finance and capital-skill complementarity. The data are expressed in current Euro values. We deflate the figures using a country- and sector-specific price index.

More specifically, the steps of the data preparation process we apply are the following:

- Keep only unconsolidated accounts when both consolidated and unconsolidated accounts are available:

- Keep the observation with the largest values of operating revenue when there are duplicates in firm ID and closing date; i) Filter the year from the closing date by using the current year if the month is later than June and using the previous year if the month is earlier than June; ii) for each firm-year, keep the one with the latest reporting date.

- Cancel reporting mistakes:
  i) drop observations with information on total assets, operating revenues, sales, and employment all missing;
  ii) drop observations with negative total assets, employment, sales, or tangible fixed assets;
  iii) drop observation of firms with the number of employees exceeds 1 million in any year;
  iv) Exclude observations with negative current liabilities, noncurrent liabilities, current assets, loans, creditors, other current liabilities, or long-term debt;
  v) exclude the observations if their long-term debts are higher than the liability;
  vi) Exclude Firms implying non-positive age values in any year;
  vii) Drop observations with negative values for intangible fixed assets, and drop observations with missing or zero values for tangible fixed assets;
  vii) Drop observations with missing, zero, or negative values for the wage bill;
  ix) Drop observations with negative depreciation values;

- Check for extreme values. Exclude observations that are either below the 0.1 percentile or above the 0.99 percentile of the distribution of:
  i) the ratio of fixed assets (the sum of tangible fixed assets, intangible fixed assets, and other fixed assets) to total assets;
  ii) the ratio of the sum of stocks, debtors and other current assets to total current assets;
  iii) the ratio of the sum of fixed assets and current assets to total assets;
  iv) the ratio of the sum of capital and other shareholder funds to total shareholder funds;

v) the ratio of the sum of long-term debt and other non-current liabilities to total non-current liabilities;
vi) the ratio of the sum of loans, creditors and other current liabilities to total current liabilities;
vii) the ratio of the sum of non-current liabilities, current liabilities and shareholder funds to total shareholder funds and liabilities;
viii) we define liabilities as the difference between total shareholders' funds and liabilities, and the shareholders' funds, then drop the observations if the value is negative or zero. Further, we obtain liabilities by adding current and noncurrent liabilities. We drop the observations if the ratio between the two definitions of liabilities is greater than 1.1 or lower than 0.9;
ix) We define net worth as the difference between total assets and liabilities, keeping the observations with the net worth equal to shareholder funds;
x) Drop observations when the ratio of tangible fixed assets to total assets is greater than one;
xi) We define the capital-labor ratio where the capital stock is the sum of tangible and intangible fixed assets. Firms reporting a capital-labor ratio in the bottom 0.1 percentile. We drop the firm-year observations with a capital-labor ratio higher than the 99.9 percentile or lower than the 0.1 percentile;
xii) Keep observations with positive shareholder funds, while the observations with the ratio of other shareholder funds to total assets in the bottom 0.1 percentile are dropped;
xiii) Drop extreme values in the bottom 0.1 or top 99.9 percentile of the distribution of two leverage indicators defined as: i) the ratio of tangible fixed assets to shareholder funds and ii) the ratio of total assets to shareholder funds; xiv) We define the value added as the difference between operating revenues and material costs, keeping the observations with a positive value added;

- To deflate the variables, we consider three measures of GDP deflators, two at a country-sector level and one at the national level. Specifically, we deflate all the financial variables of our dataset, exploiting the country-specific deflator. Then, we deflate the two measures of value added and material costs using the measure of national accounts aggregates by industry (`nama_10_a64` on EUROSTAT), while investments and capital are deflated using the measure of gross capital formation by industry (`nama_10_a64_p5` on EUROSTAT). We group the different sectors at a two-digit NACE category level, sharing the same deflator for different subsectors. This approach allows us to keep the highest possible level of observations. All the deflator measures are calculated as a ratio of current prices to chain-linked volumes, with 2005 as the base year.