Credit Constraints, Labor Productivity and the Role of Regional Institutions: Evidence for Manufacturing Firms in Europe*

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Abstract: This paper examines the relationship between credit constraints − proxied by the investment-to-cash flow sensitivity – and firm-level economic performance − defined in terms of labor productivity – during the period 2009-2016, using a sample of 22,380 manufacturing firms from 11 European countries. It also assesses how regional institutional quality affects productivity at the level of the firm both directly and indirectly. The empirical results highlight that credit rationing is rife and represents a serious barrier for improvements in firm-level productivity and that this effect is far greater for micro and small than for larger firms. Moreover, high-quality regional institutions foster productivity and help mitigate the negative credit constraints-labor productivity relationship that limits the economic performance of European firms. Dealing with the European productivity conundrum thus requires greater attention to existing credit constraints for micro and small firms, although in many areas of Europe access to credit will become more effective if institutional quality is improved.

Keywords: Credit Constraints; Labor Productivity; Manufacturing Firms; Regional Institutions; Cross-Country Analysis; Europe.

JEL Codes: C23; D24; G32; H41; R12.

1. INTRODUCTION

Economic growth, in general, and firm-level growth, in particular, is highly dependent on the presence of efficient financial markets (Levine and Zervos 1998; Rajan and Zingales 1998; Greenwood et al. 2013). Weak or inefficient financial markets stifle economic activity and aggravate the negative effects of downturns and economic crises on economies and firms alike (Gilchrist and Zakrajšek 2012). Easy access to finance expedites firm-level investments, facilitates physical and human capital accumulation, as well as the development and adoption of new technologies, positively affecting firms' performance and raising total factor productivity (Beck et al. 2000; Redmond and Van Zandweghe 2016).

Imperfectly functioning financial markets, by contrast, lead to capital misallocation. In these contexts, capital may elude some of the most innovative and productive firms (Buera et al. 2011; Midrigan and Xu 2014; Moll 2014; Gopinath et al. 2017). Investment declines as firms unable to access credit forego profitable and productivity-boosting investment opportunities (Campello et al. 2010; Manaresi and Pierri 2017). Credit constraints are also critical in curbing firm-level research and development (R&D) spending (Aghion et al. 2012), as intangible investments are less collateralizable (Lee et al. 2015). Finally, investment in disruptive innovation – the type of innovation that can result in the greatest leapfrogs in productivity and growth – is mostly compromised in ecosystems with strong credit constraints (Caggese 2019).

It therefore comes as no surprise that geographical areas dominated by relatively inefficient financial markets generally struggle to transform latent economic potential into economic activity and productivity growth. Hence, if inefficient financial markets and credit constraints smother economic activity and prevent productivity growth, why is it so difficult to remedy this problem?

One of the key reasons for the persistence of negative returns of financial market inefficiencies on firms' performance is that the mechanisms behind the relationship between credit constraints and firm-level productivity at the local level are still poorly understood. This paper contributes to fill this gap by analyzing not only the extent to which credit constraints affect European manufacturing firms' labor productivity and how sensitive are these potential constraints to differences in firm size, but also by gauging whether regional institutional quality plays a role in determining the firm-level credit constraints-labor productivity relationship.

First, credit constraints can be a major culprit of low productivity in many parts of Europe. They also tend to hurt smaller firms to a greater extent than larger ones (Ferrando and Ruggieri 2018). Smaller firms generally face more difficulties in accessing credit from banks and other financial institutions than larger ones (Andrieu et al. 2018). Access constraints to external financial resources undermine their investment possibilities and, as a result, their efficiency, productivity and growth potential (Ganau 2016; Motta 2020). Second, the potentially negative returns of credit constraints on firms' productivity may be influenced by the quality of government of the places where firms are located. High-quality local governments can influence firm-level productivity positively both directly – by adequately defining the "formal" institutional context where firms operate (Lasagni et al. 2015; Ganau and Rodríguez-Pose 2019) – and indirectly – by alleviating the negative returns of credit rationing through the development of a business environment based on safety, certainty and stability, where the conditions for inter-firm trade credit among local firms are maximized (Ferrando and Mulier 2013; Ganau 2016; McGuinness et al. 2018).

The key contribution of this paper involves blending together the literature on the economic returns of credit constraints on firm-level productivity with that covering regional institutional quality, in order to evaluate whether and to what extent sub-national institutional quality represents a factor attenuating or exacerbating the negative productivity returns of inefficient financial markets.

The empirical analysis employs a sample of 22,380 manufacturing firms observed over the period 2009-2016 from 11 European countries – Belgium, Bulgaria, Czech Republic, France, Germany, Hungary, Italy, Portugal, Romania, Slovakia and Spain. The results highlight that credit rationing represents a serious barrier for improvements in firm-level productivity and that this negative effect is greater for smaller than for larger firms. Moreover, high-quality regional institutions foster firms' labor productivity directly, and help mitigate the negative credit constraints-labor productivity relationship.

The rest of the paper is structured as follows. Section 2 presents the theoretical arguments and derives the research hypotheses. Section 3 introduces the dataset, the empirical model, and the econometric approach. Section 4 reviews and discusses the empirical results. Section 5 concludes the work and draws some preliminary policy implications.

2. THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESES

2.1. Credit constraints and firms' productivity

In a frictionless world of perfectly efficient financial markets all profitable projects would get financed and firms would be indifferent to use their internal capital, debt, or equity (Modigliani and Miller 1958). However, the real world is far from being frictionless and credit market distortions abound, leading to difficulties for specific firms in raising credit from financial institutions.

Credit constraints arise from information asymmetries between firm managers and finance providers. The latter often lack all the information on the firm's circumstances, making discriminating *ex ante* between high- and low-quality projects difficult and, more importantly for them, costly. Credit institutions thus incur high fixed costs related to the assessment and monitoring of projects, which ultimately result in higher interest rates and a *de facto* rationing of the amount of credit available. Consequently, many potentially profitable investments are credit rationed (Stiglitz and Weiss 1981).

The fundamental consequence of credit rationing for firms is that they have to rely on internally-generated resources to undertake productivity-boosting investment projects, such that investment opportunities and decisions become highly dependent on cash flow availability (Ayyagari et al. 2011). In other words, credit-rationed firms can enhance their productivity only if they possess the internal resources required to undertake new investments. In brief, credit rationing deprives firms from the all-important investment – e.g. in machinery, training, or R&D – that propels productivity (Love 2003; Guariglia 2008). Credit constraints can therefore smother firms' productivity (Gatti and Love 2008; Chen and Guariglia 2013; Ganau 2016; Motta 2020). Drawing on this rationale, we hypothesize that:

H_1: Firms can be credit constrained and their investment dynamics are sensitive to cash flow availability.

H_2: Credit constraints have a negative effect on firms' labor productivity.

However, credit constraints and their returns on firms' productivity are affected by various firm-level characteristics (Beck et al. 2005; Heyman et al. 2008; Psillaki and Daskalakis 2009; Brown et al. 2011; Degryse et al. 2012; Coluzzi et al. 2015). Firm size seems to play a crucial role in this respect as, overall, larger firms have easier access to credit than smaller ones (Andrieu et al. 2018). Larger firms typically have more information to share with (potential) investors, which reduces information asymmetries and opacity. They also have more options to signal their performance and more assets that can be used as collateral in loans than smaller firms. Moreover, larger firms have lower idiosyncratic and insolvency risks (Berryman 1982). Unsurprisingly, small firms with the highest credit risk are the most credit-rationed in absolute terms (Becchetti et al. 2010), and quantity-rationed in particular (ECB 2018).

Smaller firms are thus in a far worse position than larger ones to meet the requirements of banks and financial intermediaries to mitigate the problems of adverse selection and moral hazard, and are the most likely victims of credit rationing (Bellier et al. 2012). Because of these constraints, smaller firms often strict their investments to internally generated funds (Masiak et al. 2017). Therefore, we hypothesize that:

H_3: Smaller firms are more likely to be credit rationed and, therefore, more dependent on internally generated resources to engage in investments than larger firms.

H_4: The negative effects of credit constraints are greater for the labor productivity of smaller firms compared to larger firms.

2.2. Credit constraints, productivity and the regional institutional context

Besides firm size, credit rationing and its negative returns on firms' productivity may be related to the context in which firms are located and operate. The literature has widely underlined how national macroeconomic conditions, the development and regulation of the national financial sector, and the quality of national institutions are fundamental factors influencing both firms' access to credit (Canton et al. 2013; Andrieu et al. 2018; Hewa Wellalage et al. 2019) and performance (Aidis 2005; Dollar et al. 2005; Bowen and De Clercq 2008; Dutta and Sobel 2016). By contrast, how regional institutions influence firms' productivity, in general, and the credit constraints-productivity relationship, in particular, has received limited attention.

There are important sub-national differences within European countries in terms of socio-economic conditions, industrial structure, access to finance, and institutional framework. Particularly interesting is the (persistently) unequal distribution of small- and medium-sized enterprises (SME) throughout Europe, where the within-country regional variation in SMEs' density is greater than differences across countries (Nistotskaya et al. 2015). This type of regional heterogeneity is of great relevance, since SMEs are usually regarded as major agents for employment generation, development and economic growth, especially in less developed regions (Aghion et al. 2007; Eraydn 2017).

Nonetheless, the capacity of SMEs to fulfil their role as economic engines is being challenged by severe problems of access to finance. As previously discussed, larger firms are more shielded from credit constraints than smaller ones, as they can typically access financial intermediaries and capital markets on a national or even international scale. SMEs, in contrast, are more dependent on local bank financing than large companies (Alessandrini et al. 2009; Lawless et al. 2015). This is particularly true in Europe, where 70% of SMEs' external financing is provided by banks (Boata et al. 2019). The combination of high dependency on bank financing and relatively high risk of credit rationing make small firms far more affected by the local context. Indeed, recent empirical research confirms the presence of a strong relationship between small firms' capital structure and the conditions and level of competition of the regional financial sector (La Rocca et al. 2010; Palacín-Sanchez et al. 2013; Palacín-Sanchez and di Pietro 2016; Klagge et al. 2017; Matias and Serrasqueiro 2017; Butzbach and Sarno 2019). Moreover, regional heterogeneity in the distribution and density of bank branches helps explaining credit restrictions encountered by firms, independently of their size (Alessandrini et al. 2009).

Consequently, as smaller firms remain more dependent than larger ones on bank lending and are also more credit rationed, they are also more inclined to rely on alternative, non-institutional sources of funding. Indeed, they use trade credit for short-term financing (Petersen and Rajan 1995; Berger and Udell 1998; Ogawa et al. 2013), obtain state subsidies (Gerritse and Rodríguez-Pose 2018), or rely on informal sources of finance – such as family or friends (Chavis et al. 2011; Hanedar et al. 2014). Only by following these various channels they can overcome bank credit restrictions and thus expand investment opportunities otherwise based solely on the available cash flow (Masiak et al. 2017).

In this respect, regional institutional conditions may represent a key factor for firms – and, in particular, for SMEs – to relax credit rationing-related barriers to productivity. Differences in regional institutions in Europe and beyond – from the United States to China – have attracted considerable attention in recent years. Sub-national government quality has featured prominently in studies aiming at explaining persistent regional differentials in economic performance (Kim and Law 2012; Charron and Lapuente 2013; Rodríguez-Pose 2013; Ketterer and Rodríguez-Pose 2018; Rodríguez-Pose and Zhang 2019), as the variation in governance and institutional quality remains large (Tomaney 2014).

Regional government quality affects firms' behavior and performance through different channels, as regional institutions shape operations in the local business environment (Sobel 2015). High-quality local governments can boost firms' productivity by, for example, guaranteeing market competition, a transparent and fair juridical system, the enforcement of contracts, the protection of property rights, and the fight against corruption (Lasagni et al. 2015; Ganau and Rodríguez-Pose 2018, 2019). In addition, over a half of public investment in Europe is carried out at the regional and local level (OECD 2018), such that more effective sub-national governments can adopt more efficient policies that are translated into greater innovation, productivity, and growth (Crescenzi et al. 2016). In particular, poor government quality damages the productivity of smaller, less capital endowed firms (Ganau and Rodríguez-Pose 2019), as they are often ill-equipped to deal with unfair treatment and, typically, have less leverage to influence local decision-making (Slinko et al. 2005).

Local governments can also play an indirect role in supporting firms' productivity improvements by alleviating the negative returns of credit constraints. "Good" formal institutions can promote a "safe" and stable local business environment, where increased reputation and trust among business partners (suppliers and customers) facilitate repeated production transactions and, through these, the emergence of inter-firm financial relationships (Dei Ottati 1994; Scalera and Zazzaro 2011; Cainelli et al. 2012). Trade credit – that can materialize through better contracts or delayed payments – represents a key alternative source of financing for firms to alleviate credit constraints. It is particularly relevant for smaller than for larger firms, as the former are traditionally more embedded in the local productive environment in terms of backward and forward linkages (Ogawa et al. 2013; Deloof and La Rocca 2015; Ganau 2016; McGuinness et al. 2018).

Therefore, drawing on this rationale, we hypothesize that:

$H_{5(a)}$: High-quality regional institutions support firms' labor productivity improvements.

$H_{5(b)}$: The positive returns of high-quality regional institutions on labor productivity are higher for smaller than for larger firms.

$H_{6(a)}$: High-quality regional institutions alleviate the negative returns of credit constraints on firms' labor productivity.

$H_{6(b)}$: The positive moderation effect of high-quality regional institutions is greater for smaller than for larger firms.

3. EMPIRICAL FRAMEWORK

3.1. Dataset

The firm-level data used in the empirical analysis are drawn from the *Amadeus* database (*Bureau van Dijk*), which provides balance sheet data and personal information for European firms. The original sample has been cleaned to consider only active manufacturing firms reporting unconsolidated financial statements. Firms without information on incorporation year, geographic location at the sub-national level − defined according to the European Union (EU) *Nomenclature des Unités Territoriales Statistiques* (NUTS) − and industrial sector at the two-digit level of the EU NACE Rev. 2 Classification have been removed. The sample has been cleaned also by culling firms reporting missing figures for tangible fixed assets and depreciations over the period 2008-2016 in order to estimate firm-level variables for real investments in tangible fixed assets and capital stock for the years from 2009 to 2016. The resulting sample has been further polished by considering only firms reporting strictly positive figures for investments, capital stock, cash flow, value added, employment, and sales for at least three consecutive years during the period 2009-2016. The cleaning procedure left a sample of firms covering 11 European countries – Belgium, Bulgaria, Czech Republic, Germany, France, Hungary, Italy, Portugal, Romania, Slovakia and Spain. Finally, due to differences in the cross- and within-country representativeness of firms in the *Amadeus* database, the final sample has been obtained by randomly drawing a 20% of firms stratified in order to reflect both absolute cross-country representativeness and relative within-country representativeness in terms of two-digit NACE Rev. 2 industrial sector, sub-national geography defined according to the NUTS classification, and size with respect to official figures derived from the Structural Business Statistics (SBS) provided by the European Statistical Office (Eurostat). Firm size classes are defined according to the EU Recommendation No. 2003/361. This recommendation classifies firms as (i) micro, if the number of employees is lower than 10; (ii) small, if the number of employees ranges in the interval $[10, 49]$; (iii) medium, if the number of employees ranges in the interval $[50, 249]$; and (iv) large, if the number of employees is equal to or greater than 250.[1]

The randomized selection procedure resulted in a cleaned final sample of 22,380 firms observed over the period 2009-2016.[2] Appendix A (Electronic Supplementary Material) reports some descriptive statistics of the sample of firms.

The firm-level dataset has been then integrated with region-specific data series. First, data on region-level institutional quality from the European Quality of Government Index (EQGI) dataset (Quality of Government Institute, University of Gothenburg) has been added. The EQGI provides information derived from citizen-based surveys conducted in 2010 and 2013 on the perception and experience of individuals with respect to corruption, quality, and impartiality in terms of education, public health care, and law enforcement – see Charron et al. (2013) and Charron et al. (2014, 2015) for details. Second, regional data on population, Gross Domestic Product (GDP), human capital (defined as percentage of population aged 25-64 years with tertiary education), and unemployment rate (defined as percentage of the unemployed population aged 15-74 years) are extracted from Eurostat's *Regio* database.

3.2. Empirical Model

The empirical analysis aims at evaluating, first, the extent to which firms suffer from credit constraints and, second, whether credit constraints represent an obstacle to firm-level labor productivity. Furthermore, it assesses whether the quality of regional institutions affects firms' labor productivity and the credit constraints-labor productivity relationship.

The empirical modelling consists of estimating a system of two equations defined by a first-

[1] The choice of developing the empirical analysis on a sample randomly drawn from the *Amadeus* database presents both advantages and disadvantages. Among the disadvantages, the choice has implications in terms of a loss in the number of observations and reduced significance levels. The main advantage is that it increases the representativeness of the sample with respect to the true population of firms operating in the countries analyzed. This latter aspect is particularly relevant given the cross-country nature of the analysis, as well as the fact that we use a geographic-based measure of institutions defined at the sub-national level and focus on size-based sub-samples of firms.

[2] One of the drawbacks of the *Amadeus* database is that it does not allow the identification of multi-establishment firms. This issue is, in any case, partially relaxed by the exclusion from the sample of firms reporting consolidated financial statements, as well as by the fact that about the 67% of the sample is made of micro- and small-sized firms. Firms of this size tend to be overwhelmingly mono-establishment (Cainelli and Iacobucci 2011, 2012).

step investment equation and a second step labor productivity equation (Ganau 2016). This operational choice reflects the absence of any direct information on the credit-constrained status for individual firms. Unfortunately, no information on whether an individual firm was denied credit by a bank or financial institution is available. Consequently, firm-level credit constraints are proxied by means of estimating the investment-to-cash flow sensitivity, i.e. by the sensitivity of firms' investments to internally generated resources captured by the available cash flow. Although investment-to-cash flow sensitivity may not always be a perfect proxy for credit constraints (Kaplan and Zingales 1997), it has been widely adopted in the financial empirical literature since the seminal work of Fazzari et al. (1988). The rationale is that firms affected by credit constraints have to rely on internal resources to finance new investments and, thus, additional cash flow can allow them to optimize real investments (Bond and Van Reenen 2007; Hernando and Martínez-Carrascal 2008; Carreira and Silva 2010). Therefore, the first step of the empirical modelling consists in estimating a dynamic investment equation to analyze firm-level investment-to-cash-flow sensitivity, that is, to evaluate whether firms' real investments depend on internally-generated resources and to retrieve a firm-level measure of credit constraints.

Formally, let i denote the firm operating in the two-digit sector s and located in region r in country c at time t. Then, by adopting an Error Correction Model-type (ECM) specification in the spirit of Bond et al. (2003) and Bloom et al. (2007), the dynamic investment equation is defined as follows:

$$\log\left(\frac{I_{isrct}}{Kb_{isrct}}\right) = \alpha_0 + \alpha_1 \log\left(\frac{I_{isrct-1}}{Kb_{isrct-1}}\right) + \alpha_2 \log\left(\frac{CF_{isrct}}{Kb_{isrct}}\right) + \alpha_3 \Delta Sales_{isrct}$$
$$+\alpha_4[\log(K_{isrct-1}) - \log(Sales_{isrct-1})] + \alpha_5 \log(LP_{isrct-1}) + \alpha_6 \log(Age_{isrct})$$
$$+\alpha_7 \log(Size_{isrct}) + \varepsilon_{isrct}$$
$$\varepsilon_{isrct} = v_i + v_s + v_c + v_t + v_{isrct} \quad (1)$$

where the dependent variable denotes real investments in tangible fixed assets (I_{isrct}) scaled by the beginning of the period capital stock (Kb_{isrct}).[3] The key explanatory variables in Equation (1) are the first-order time-lagged scaled investment variable and the variable capturing scaled cash flow (CF_{isrct}/Kb_{isrct}) – where cash flow is defined as net income plus depreciations. These variables allow us to assess firms' investments sensitivity to internally generated resources. A positive and statistically significant estimated coefficient of the cash flow variable (α_2) can be interpreted as evidence of credit constraints.

The right-hand side of Equation (1) includes also the change in sales between periods t and $t-1$ ($\Delta Sales_{isrct}$) to capture the short-run response of investments to demand shocks and the error correction term, defined as the difference between capital stock (K_{isrct}) and sales ($Sales_{isrct}$) at time $t-1$. The latter term denotes the adjustment speed of capital stock to its equilibrium level. Equation (1) is further augmented by including the first-order time-lagged labor productivity variable ($LP_{isrct-1}$), defined as deflated value added over employment; the age variable (Age_{isrct}), defined as the year of observation minus the incorporation year of a firm; and the size variable ($Size_{isrct}$), measured in terms of employment. Finally, the composite error term ε_{isrct} is defined as the sum of five components: v_i denoting firm fixed effects; v_s representing a set of two-digit sector dummies; v_c denoting country dummies; v_t denoting year dummies; and v_{isrct} denoting the error term.[4]

The second step of the empirical modelling consists of specifying a labor productivity equation to analyze the credit constraints-labor productivity relationship, where labor productivity is defined as deflated value added over employment. This facilitates testing for both the direct role of regional institutional quality on firm-level performance and its indirect role as a potential moderating factor of the credit constraints-labor productivity relationship. The labor productivity equation is specified as follows:

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[3] Appendix B (Electronic Supplementary Material) provides details on the computation of the firm-level variables for investments and capital stock.

[4] The ECM presents four main advantages over the alternative and widely employed Q model (Guariglia 2008). First, the ECM is more flexible than the Q model. This could help reducing misspecification problems. Second, the ECM maintains the long-run properties of the standard value-maximizing investment model. Third, it also allows for short-run dynamics in adjustment costs. Finally, it is possible to estimate an ECM specification for both unlisted and listed firms, while the calculation of Tobin's Q would be possible for listed companies only, as it requires knowing the firm's market value.

$$\begin{aligned}\log(LP_{isrct}) = {} & \beta_0 + \beta_1 Credit\ Constraint_{isrct} + \beta_2 Institutional\ Quality_{rct} \\ & + \beta_3 (Credit\ Constraint_{isrct} \times Institutional\ Quality_{rct}) + \beta_4 \log(Age_{isrct}) \\ & + \beta_5 \log(Size_{isrct}) + \beta_6 \Delta Size_{isrct} + \beta_7 \log(K_{isrct}/Employment_{isrct}) \\ & + \beta_8 \log(Sales_{isrct}) + \beta_9 \log(Population_{rct}) + \beta_{10} \log(GDP_{rct}/Population_{rct}) \\ & + \beta_{11} \log[HC_{rct}/(1 - HC_{rct})] + \beta_{12} \log[UR_{rct}/(1 - UR_{rct})] \\ & + \boldsymbol{\vartheta}_i + \boldsymbol{\kappa}_t + v_{isrct} \qquad (2)\end{aligned}$$

where labor productivity (LP_{isrct}) is a function of the estimated firm-level investment-to-cash flow sensitivity ($Credit\ Constraint_{isrct}$), i.e. the elasticity of investments to cash flow computed at the firm-year observation level, from Equation (1), and the region-specific variable for institutional quality ($Institutional\ Quality_{rct}$), which captures the level of institutional quality in region r in country c at time t. These two explanatory variables allow us to evaluate whether firms' labour productivity is held back by credit constraints and whether it benefits from location in a regional ecosystem characterized by a "good" institutional setting, respectively. The right-hand side of Equation (2) also includes the interaction term between the two abovementioned variables to evaluate whether any credit constraints-related shortcomings to firm-level labor productivity are moderated by high-quality regional institutions.[5]

Following the approach proposed by Charron et al. (2014, p. 83), the regional institutional quality variable is constructed by interpolating the EQGI survey questions with the dimensions of government effectiveness, control of corruption, rule of law, and government accountability also

[5] A positive estimated coefficient of the interaction term is interpreted as evidence of a positive moderation effect of regional institutional quality on the negative credit constraints-labour productivity relationship, rather than as evidence that the negative effects of "weak" institutions on labour productivity are eased by the non- or low-credit constrained condition of a firm. A "good" regional institutional framework – by facilitating the emergence of a favorable business ecosystem, allowing for trade credit and a reduction of transaction costs – can alleviate the negative productivity returns of credit rationing to a far larger extent than the non- or low-credit constrained status of a firm mitigate the negative productivity externalities arising from the location in a regional context characterized by corruption, low-quality public services, or low-effective government. Indeed, a region-specific dimension – and, particularly, a dimension such as institutional quality which is historically rooted and long-lasting (Rodríguez-Pose 2013, 2020) – is much more likely to influence a firm-specific condition, rather than the other way round.

available at country-level for the period 1996-2017 in the Worldwide Governance Indicators (WGI) dataset provided by the World Bank (Kaufmann et al. 2010). The interpolation of region- and country-specific indicators presents some advantages: first, it enables us to extend the temporal dimension of the regional institutional data to the entire period of analysis; second, it captures country-specific dimensions – e.g. legal system, immigration, trade, security − which are not accounted for by the regional data; finally, it relaxes potential biases affecting the regional data that may be induced by the limited number of respondents per region. Formally, let $\overline{WGI}_{ct}$ denote the average of the four institutional dimensions considered from the WGI dataset in country c at time t; let $EQGI_{rc}$ represent the region-specific score derived from the regional dataset and averaged over the 2010 and 2013 survey waves; and let $\overline{EQGI}_{c}^{w}$ denote the country-level population-weighted average of the region-specific score. Then, the region-specific time-varying institutional quality index (IQI_{rct}) is defined as follows:

$$IQI_{rct} = \overline{WGI}_{ct} + (EQGI_{rc} - \overline{EQGI}_{c}^{w}) \quad (3)$$

The IQI index is subsequently standardized in the interval $[0, 1]$ to obtain the institutional quality variable ($Institutional\ Quality_{rct}$). The standardization makes the interpretation of the institutional quality variable straightforward, as the institutional quality in a region increases with the value of the variable from 0 to 1 (Crescenzi et al. 2016; Ganau and Rodríguez-Pose 2019).

The right-hand side of Equation (2) also includes a set of firm-level controls, consisting of: age (Age_{isrct}); size ($Size_{isrct}$); a variable capturing the change in firm size between periods t and $t-1$ ($\Delta Size_{isrct}$); the capital-to-employment ratio variable ($K_{isrct}/Employment_{isrct}$); and a variable capturing firm sales ($Sales_{isrct}$). The model also includes a set of regional controls, encompassing: population ($Population_{rct}$) to proxy for the size of a region; regional wealth, defined as GDP per capita ($GDP_{rct}/Population_{rct}$); human capital endowment (HC_{rct}); and unemployment rate (UR_{rct}). Finally, Equation (2) includes the vectors $\boldsymbol{\vartheta}_i$ and $\boldsymbol{\kappa}_t$ of firm- and year-specific fixed effects, respectively, and the error term v_{isrct}.

Appendix C (Electronic Supplementary Material) reports the definition, some descriptive statistics, and the correlation matrix of the variables. Appendix D (Electronic Supplementary Material) presents some insights on the spatial dynamics of the key variables for labor productivity, investment-to-cash flow sensitivity, and regional institutional quality.

3.3. Econometric Approach

In line with the most recent literature analyzing firm-level investment-to-cash flow sensitivity (Bloom et al. 2007; Hernando and Martínez-Carrascal 2008; Alessandrini et al. 2009; Antonietti et al. 2015; Ganau 2016), the two-step System Generalized Method of Moments (GMM) estimator is employed to estimate the first-step dynamic investment Equation (1) to avoid a biased coefficient of the time-lagged dependent variable (Wooldridge 2002). Moreover, the System GMM estimator permits considering unobserved heterogeneity and potential endogeneity of the explanatory variables simultaneously. In fact, it combines a system of first-differenced variables − removing unobserved heterogeneity − instrumented with lagged levels, and a system of variables in level, instrumented with lags of their own first differences (Arellano and Bover 1995; Blundell and Bond 1998). The variables capturing firm age, as well as sector, country, and time fixed effects, are treated as exogenous. They are used as instruments for themselves only in levels. All other explanatory variables are, by contrast, treated as endogenous and instrumented using their second- and third-order lagged levels in the differenced equation and their second- and third-order lagged differences in the level equation. The validity of the estimation methodology is assessed through Arellano and Bond's (1991) test of serial correlation for dynamic panel data and Hansen's (1982) J statistic of over-identifying restrictions aimed at testing the null hypothesis of instruments' exogeneity.

The static nature of the second-step labor productivity Equation (2) allows us to resort to a two-way Fixed Effects (FE) estimator, which removes firm-level unobserved heterogeneity, helps mitigate omitted variable problems, and controls for temporal shocks affecting all firms in a given observational year. However, the estimation of the labor productivity Equation (2) may be affected by the potential endogeneity of the variables for credit constraints (e.g. Chen and Guariglia 2013) and regional institutional quality (e.g. Ganau and Rodríguez-Pose 2019). Endogeneity in this context could emerge due to simultaneity bias, omitted variable bias, and measurement errors. With regard to the credit constraints variable, a simultaneity bias could arise because, although increased access to external finance is expected to enhance firms' productivity, it could also be that more productive firms are in a better position to access external financial resources. Measurement errors could also arise because credit constraints are captured only indirectly, as the true constrained status of a firm – i.e. whether it was denied credit from banks or other financial institutions – is not observed. Regarding the institutional quality variable, a simultaneity bias could arise if regions with an abundance of high-productivity firms are also those with better institutions. After all, strong institutions can be a consequence of a good economic environment. Moreover, the institutional quality variable is only a proxy for what can be considered as a complex and hard to capture, measure, and operationalize phenomenon, potentially leaving to measurement errors. Finally, there are perhaps unobservable factors and exogenous shocks that could affect simultaneously regional institutional quality, access to finance, and labor productivity.

A possible solution to deal with the potential endogeneity of the credit constraints and institutional quality variables consists of specifying a dynamic version of the labor productivity Equation (2) and to rely on the two-step System GMM estimator (e.g. Chen and Guariglia 2013; Ganau and Rodríguez-Pose 2019). This strategy has two key advantages. First, it exploits the internally generated instruments to deal with potential endogeneity of all the explanatory variables. Second, it facilitates the control of time-persistence in firm-level labor productivity (e.g. Ganau and Rodríguez-Pose 2019). The dynamic version of the labor productivity Equation (2) is thus specified as follows:

$$\log(LP_{isrct}) = \beta_0 + \beta_1 \log(LP_{isrct-1}) + \beta_2 Credit\ Constraint_{isrct} + \beta_3 Institutional\ Quality_{rct}$$

$$+\beta_4(Credit\ Constraint_{isrct} \times Institutional\ Quality_{rct}) + \beta_5 \log(Age_{isrct})$$
$$+\beta_6 \log(Size_{isrct}) + \beta_7 \Delta Size_{isrct} + \beta_8 \log(K_{isrct}/Employment_{isrct})$$
$$+\beta_9 \log(Sales_{isrct}) + \beta_{10} \log(Population_{rct}) + \beta_{11} \log(GDP_{rct}/Population_{rct})$$
$$+\beta_{12} \log[HC_{rct}/(1 - HC_{rct})] + \beta_{13} \log[UR_{rct}/(1 - UR_{rct})] + \varepsilon_{isrct}$$
$$\varepsilon_{isrct} = v_i + v_s + v_c + v_t + v_{isrct} \tag{4}$$

where $LP_{isrct-1}$ denotes the first-order time-lagged labor productivity variable; the composite error term ε_{isrct} is defined as the sum firm fixed effects (v_i), two-digit sector dummies (v_s), country dummies (v_c), year dummies (v_t), and the error term (v_{isrct}); and all other variables are defined as before. The set of internally-generated instruments is defined by treating the variables capturing firm age, as well as sector, country, and time fixed effects, as exogenous, and using them as instruments for themselves only in levels; all the other explanatory variables are treated as endogenous and are instrumented using their second- and third-order lagged levels in the differenced equation, and their second- and third-order lagged differences in the level equation.

Although the use of internally generated instruments reduces endogeneity issues, the dynamic labor productivity Equation (4) is also estimated considering external instrumental variables (IV) for credit constraints and regional institutional quality, on top of the set of internally generated instruments. For the credit constraints variable, the identification strategy exploits cross-country variations in the default risk of national banking systems. Specifically, the IV is constructed as the standard deviation of the country-specific Z-score defined over a 10-year window period before each year in the sample. It is aimed at capturing the instability of national banking systems. As the Z-score captures the probability of default of a national banking system, i.e. it indicates the distance from insolvency, the chosen IV aims at capturing the variability in banks' default risk. The economic rationale behind the choice of the IV is that firms located in countries characterized by a higher instability of the banking system are more likely to face credit restrictions due to a worse and more volatile financial position of banks. If banks have less available resources and must submit to more stringent loan rules, then firms will face higher interest rates on the requested loans. Consequently, a reduced number of firms will be successful in their credit applications. Furthermore, the validity of the proposed IV relies on the fact that the relationship between national banking system volatility and firm-level labor productivity is likely to run only through the credit constrained condition of a firm. The data on countries' Z-score are drawn from the *Financial Structure Database* provided by the World Bank.[6]

For the regional institutional quality variable, the identification strategy follows previous empirical contributions that have used historical and geographic IVs to solve endogeneity problems in the context of institutional variables (e.g. Acemoglu et al. 2001; Glaeser et al. 2004; Rodrik et al. 2004).[7] In particular, our identification strategy is based on the contribution by Buggle and Durante (2017), who find a positive association between climate variability in the pre-industrial period − as a proxy for economic risk − and current levels of social trust in a cross-section of European regions. Hence, regional variations in precipitation variability during the growing season in the pre-industrial period (1500-1750) are used to instrument current levels of institutional quality at the regional level. The economic justification for the IV lies on the logic that high climate risk in a period where the subsistence of communities was based on agriculture produce called for local coordination and consensus. This led to the emergence of higher quality local institutions able to cope with climate-related risks. Drawing on North's (1990) new institutionalist idea of path dependency, current regional institutions should reflect the quality of past regional institutional settings. Besides, the proposed IV is likely to be valid because climate variability in the pre-industrialization period is an exogenous phenomenon with respect to firm-level labor productivity in subsequent periods. The IV is based on reconstructed paleoclimatic data drawn from the European Seasonal Temperature and

[6] The Z-score compares the buffer of a country's banking system (capitalization and returns) with the volatility of those returns. The World Bank country-level measure is calculated from bank-by-bank unconsolidated data from *Bankscope*.

[7] Examples for the EU case are Rodríguez-Pose and Di Cataldo (2015) and Ketterer and Rodríguez-Pose (2018) in the context of region-level analyses, and Ganau and Rodríguez-Pose (2019) in the context of firm-level analyses. Ganau and Rodríguez-Pose (2019), in particular, estimate a dynamic firm-level labour productivity equation to analyse the relationship between firm-level performance and regional institutions in a cross-section of EU countries. They use historical IVs for literacy rate, past dominations, and early Christianisation in a System GMM setting.

Precipitation Reconstruction (ESTPR) database. The database provides grid cells of 0.5° width containing yearly seasonal observations for the period 1500-2000 (Luterbacher et al. 2004; Pauling et al. 2006). Specifically, the IV is constructed as follows. First, season-specific inter-annual standard deviation measures of precipitations are calculated at the cell level for all years from 1500 − i.e. the first available year in the database − to 1750, which can be considered the starting year of the Industrial Revolution. Second, the cell-level standard deviation measures are averaged for all cells within a region r to obtain region- and season-specific measures of precipitation variability. Third, the region- and season-specific inter-annual standard deviation measures defined over the period 1500-1750 are averaged with respect to the spring and summer seasons − which are the growing seasons in Europe.

The two-equation system made up by the investment and labor productivity equations is estimated for both the whole sample of firms, and for the sub-samples of micro-, small-, medium- and large-sized firms in order to account for size-related heterogeneity. The bootstrapping technique is used to correct standard errors, given the "generated regressor problem" (Wooldridge 2002) arising from the inclusion of the firm-level investment-to-cash-flow sensitivity variable estimated from Equation (1) as explanatory variable in Equations (2) and (4).

4. EMPIRICAL RESULTS

4.1. Main Results

Table 1 presents the results of the two-step System GMM estimation of the dynamic investment Equation (1). The relevant statistical tests support the adopted estimation strategy. Arellano and Bond's (1991) test identifies the presence (absence) of first- (second-)order serial correlation in the first differenced residuals. Hansen's (1982) J statistic of over-identifying restrictions fails to reject the null hypothesis of instruments' exogeneity. The mean Variance Inflation Factor (VIF) value is well below the conservative cut-off value of 10 for multiple regressions, rejecting the hypothesis of multicollinearity.

Table 1: Dynamic investment equation.

Dependent Variable	$\log(I_{isrct}/Kb_{isrct})$					
Estimation Approach	System GMM					
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(I_{isrct-1}/Kb_{isrct-1})$	0.069****	0.069****	0.071****	0.072****	0.078****	0.109****
	(0.008)	(0.014)	(0.013)	(0.012)	(0.010)	(0.010)
$\log(CF_{isrct}/Kb_{isrct})$	…	…	0.470****	0.512****	0.621****	0.236***
			(0.133)	(0.058)	(0.058)	(0.079)
$\Delta Sales_{isrct}$	…	…	…	0.105***	0.240****	0.799****
				(0.040)	(0.059)	(0.163)
$\log(K_{isrct-1}) - \log(Sales_{isrct-1})$	…	…	…	…	-0.207****	-0.660****
					(0.055)	(0.141)
$\log(LP_{isrct-1})$	…	…	…	…	…	0.409****
						(0.101)
$\log(Age_{isrct})$	…	…	…		…	-0.195****
						(0.040)
$\log(Size_{isrct})$	…	…	…	…	…	-0.318**
						(0.157)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	46.35 [0.000]	38.75 [0.000]	45.26 [0.000]	55.51 [0.000]	112.23 [0.000]	74.65 [0.000]
AR (1) (p-value)	0.000	0.000	0.000	0.000	0.000	0.000
AR (2) (p-value)	0.147	0.160	0.286	0.306	0.593	0.281
Hansen J Statistic (p-value)	0.107	0.136	0.110	0.173	0.189	0.741
Mean VIF	2.03	2.03	2.01	1.99	2.00	2.28

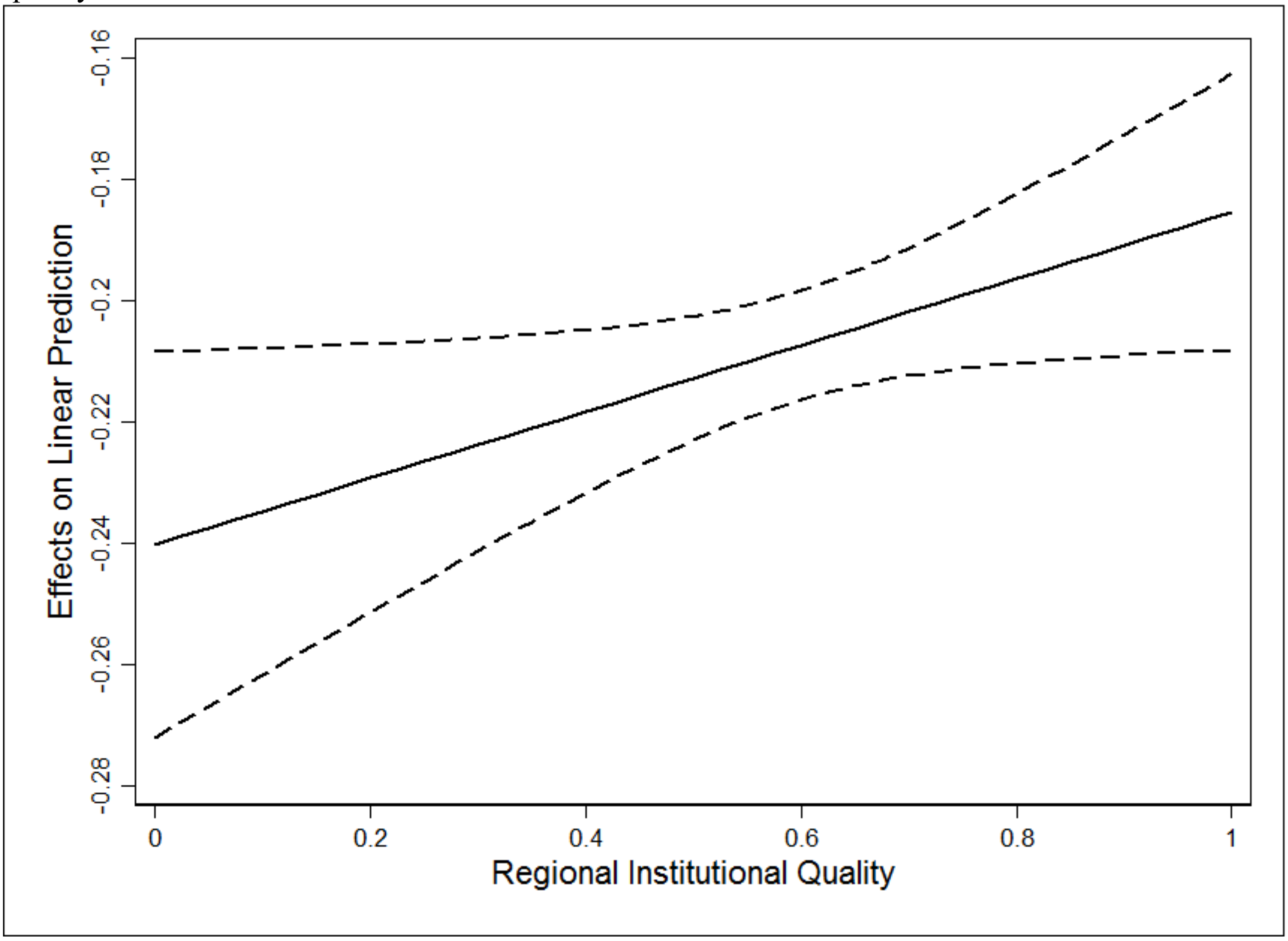
Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Standard errors are reported in parentheses. They are robust to heteroskedasticity in Specification (1), while clustered at the region level in Specifications (2) to (6). All specifications include a constant term. Specification (6) represents the first-step equation of the two-equation system, and clustered standard errors are bootstrapped. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; K stands for capital stock; LP stands for labour productivity. VIF denotes the Variance Inflation Factor. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences.

The results suggest that firm-level investment dynamics are time-persistent and that real investments are positively associated with cash flow. This last result can be interpreted as evidence of firms being affected by credit rationing, confirming hypothesis H_1. There is also evidence of short-run adjustment in the investment decisions due to demand shocks, as well as of adjustment of the current investment rate to its long-run equilibrium level. Finally, real investments are positively associated with time-lagged labor productivity levels, while negatively associated with the size and the age of the firm.

Specification (6) in Table 1 represents the first-step investment equation used to estimate the firm-level investment-to-cash-flow sensitivity variable entering the second-step labor productivity Equation (2), which allows us to evaluate the association between credit constraints and firms' productivity, as well as the (direct and indirect) role played by regional institutional quality.

Table 2 reports the two-way FE estimates of Equation (2). The estimated coefficients of the labor productivity equation are consistent in terms of sign and significance across the various specifications. Looking at the explanatory variables of interest, the results highlight a negative and statistically significant coefficient of the credit constraints variable. This result confirms hypothesis H_2 and indicates that firms' labor productivity is impaired by credit rationing. The regional institutional quality variable is positively and significantly associated with firms' labor productivity, implying that high-quality local institutions are an asset for firm-level productivity – confirming hypothesis $H_{5(a)}$. In addition, the estimated coefficients of the interaction term between the firm-level variable for credit constraints and the region-level institutional quality variable are positive and statistically significant, meaning that institutional quality at the regional level also moderates the negative credit constraints-labor productivity relationship – corroborating hypothesis $H_{6(a)}$. Figure 1 displays this relationship graphically by plotting the estimated marginal effect of investment-to-cash-flow sensitivity on labor productivity derived from Specification (5) in Table 2. The estimated credit constraints-labor productivity association is negative but positively sloped with respect to the level of regional institutional quality. In particular, the negative returns of credit constraints on labor productivity diminish from -24% to -19% when moving from the 1st to the 99th percentile of the distribution of regional institutional quality. In other words, "good" government quality compensates to a certain extent for the negative effects of credit constraints on firm-level productivity. A possible explanation for this indirect role played by high-quality regional institutions is that they increase trust and reputation among local firms, which, in turn, are more inclined to grant better contracts and delayed payments that help alleviating credit restrictions encountered by business partners in the financial market.

Figure 1: Credit constraints, labour productivity and the moderation effect of regional institutional quality.



Notes: The plot represents the estimated marginal effect of credit constraints on labour productivity at the various levels of regional institutional quality. The estimated marginal effects are derived from the interaction term in Specification (5) in Table 2. The solid line refers to the estimated effects, while the dashed lines refer to the associated 90% confidence intervals.

Table 2: Investment-to-cash flow sensitivity, labour productivity and regional institutional quality.

Dependent Variable	$\log(LP_{isrct})$				
Estimation Approach	Two-Way FE				
	(1)	(2)	(3)	(4)	(5)
$\log(Age_{isrct})$	-0.040***	-0.041***	-0.041****	-0.040***	-0.041****
	(0.013)	(0.013)	(0.012)	(0.013)	(0.012)
$\log(Size_{isrct})$	-0.583****	-0.583****	-0.586****	-0.582****	-0.585****
	(0.019)	(0.019)	(0.019)	(0.019)	(0.019)
$\Delta Size_{isrct}$	-0.178****	-0.178****	-0.177****	-0.179****	-0.178****
	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
$\log(K_{isrct}/Employment_{isrct})$	0.087****	0.086****	0.085****	0.086****	0.085****
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
$\log(Sales_{isrct})$	0.520****	0.520****	0.516****	0.521****	0.517****
	(0.019)	(0.019)	(0.018)	(0.019)	(0.019)
$Credit\ Constraint_{isrct}$	-0.205****	-0.205****	-0.205****	-0.239****	-0.240****
	(0.006)	(0.006)	(0.006)	(0.019)	(0.019)
$Institutional\ Quality_{rct}$	…	0.232***	0.120**	0.352***	0.245***
		(0.086)	(0.054)	(0.117)	(0.086)
$Credit\ Constraint_{isrct} \times Institutional\ Quality_{rct}$	…	…	…	0.054*	0.055*
				(0.031)	(0.031)
$\log(Population_{rct})$	…	…	-0.247**	…	-0.275**
			(0.112)		(0.115)
$\log(GDP_{rct}/Population_{rct})$	…	…	0.252****	…	0.236****
			(0.066)		(0.065)
$\log[HC_{rct}/(1 - HC_{rct})]$	…	…	0.021	…	0.022
			(0.019)		(0.020)
$\log[UR_{rct}/(1 - UR_{rct})]$	…	…	-0.006	…	-0.009
			(0.013)		(0.013)
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	1,422.52 [0.000]	1,312.76 [0.000]	1,096.73 [0.000]	1,344.69 [0.000]	1,194.35 [0.000]
R^2	0.64	0.64	0.64	0.64	0.64
Adjusted R^2	0.51	0.51	0.51	0.51	0.51
Mean VIF	2.31	2.33	2.45	3.90	3.70
Average Marginal Effect of Credit $Constraint_{isrct}$	…	…	…	-0.205****	-0.205****
				(0.006)	(0.006)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. LP stands for labour productivity; K stands for capital stock; GDP stands for Gross Domestic Product; HC stands for human capital, defined as percentage of population aged 25-64 with tertiary education; UR stands for unemployment rate. VIF denotes the Variance Inflation Factor. The labour productivity equations represent the second-step equations of the two-equation system, and the variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equation presented in Specification (6) in Table 1.

Table 3 reports the key results of the two-step System GMM estimation of the dynamic labor productivity Equation (4), which allows us to address endogeneity issues. As before, the firm-level investment-to-cash-flow sensitivity variable is derived from Specification (6) in Table 1. Specifications (1) and (2) are estimated by relying on internally-generated instruments only; Specifications (3) and (4) add the external IV for regional institutional quality to the set of internally-generated instruments; Specifications (5) and (6) add the external IV for credit constraints to the set of internally-generated instruments; while Specifications (7) and (8) consider the external IVs for both credit constraints and regional institutional quality, in addition to the set of internally generated instruments. The adopted estimation strategy is supported by both Arellano and Bond's (1991) test for serial correlation and Hansen's (1982) J statistic of over-identifying restrictions. The estimated coefficients of the first-order, time-lagged labor productivity variable suggest that the dynamics of a firm's labor productivity is time-persistent. Additionally, the previous results are fully confirmed. They suggest a negative relationship between labor productivity and credit constraints, a positive relationship between labor productivity and regional institutions, and a positive moderation effect played by regional institutions on the negative credit constraints-labor productivity relationship.

Table 3: Investment-to-cash flow sensitivity, labour productivity and regional institutional quality – Dynamic labour productivity equation.

Dependent Variable	$\log(LP_{isrct})$							
Estimation Approach	System GMM							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log(LP_{isrct-1})$	0.383****	0.385****	0.390****	0.388****	0.373****	0.375****	0.386****	0.377****
	(0.028)	(0.024)	(0.027)	(0.023)	(0.027)	(0.024)	(0.027)	(0.024)
$\text{Credit Constraint}_{isrct}$	-0.238****	-0.302****	-0.237****	-0.298****	-0.233****	-0.286****	-0.236****	-0.301****
	(0.009)	(0.033)	(0.009)	(0.033)	(0.009)	(0.030)	(0.010)	(0.032)
$\text{Institutional Quality}_{rct}$	0.276*	0.487**	0.140*	0.314**	0.362**	0.262*	0.159**	0.283**
	(0.149)	(0.193)	(0.075)	(0.149)	(0.163)	(0.132)	(0.077)	(0.130)
$\text{Credit Constraint}_{isrct} \times \text{Institutional Quality}_{rct}$	…	0.112**	…	0.105**	…	0.089*	…	0.110**
		(0.050)		(0.050)		(0.046)		(0.048)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	1,688.19 [0.000]	2,480.85 [0.000]	3,060.30 [0.000]	1,975.24 [0.000]	1,463.19 [0.000]	2,501.23 [0.000]	3,120.80 [0.000]	2,239.54 [0.000]
AR (1) (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR (2) (p-value)	0.244	0.189	0.243	0.245	0.211	0.256	0.227	0.317
Hansen J Statistic (p-value)	0.863	0.991	0.775	0.995	0.860	0.991	0.818	0.992
Internally Generated Instruments	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
External IV for								
$\text{Institutional Quality}_{rct}$	No	No	Yes	Yes	No	No	Yes	Yes
$\text{Credit Constraint}_{isrct}$	No	No	No	No	Yes	Yes	Yes	Yes
Average Marginal Effect of $\text{Credit Constraint}_{isrct}$	…	-0.231****	…	-0.231****	…	-0.229****	…	-0.231****
		(0.008)		(0.007)		(0.007)		(0.007)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. All specifications include a constant term. LP stands for labour productivity. The labour productivity equations represent the second-step equations of the two-equation system, and the variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equation presented in Specification (6) in Table 1. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t-1$ to $t-10$. Both external IVs are used only in levels in the two-step System GMM approach.

A clearer picture of this last result emerges from Table 4. This table reports the estimated marginal effect of credit constraints on labor productivity at selected percentiles of the regional institutional quality variable. It allows us to "disentangle" the interaction term between the variables for credit constraints and regional institutional quality. The relationship between labor productivity and credit constraints remains negative for all the selected percentiles of the distribution of the regional institutional quality variable, but its magnitude diminishes as the quality of local institutions improves. This confirms that "good" institutional quality helps mitigate the negative returns of credit rationing on firms' labor productivity.[8]

Table 4: Credit constraints, labour productivity and the moderation effect of regional institutional quality − Dynamic labour productivity equation.

Marginal Effect of Credit $\text{Constraint}_{isrct}$ on $\log(LP_{isrct})$				
Estimation Approach	System GMM			
Corresponding Specification in Table 3	(2)	(4)	(6)	(8)
Percentiles of Institutional Quality_{rct}				
1st	-0.302****	-0.298****	-0.286****	-0.301****
	(0.033)	(0.033)	(0.030)	(0.032)
25th	-0.241****	-0.240****	-0.237****	-0.240****
	(0.009)	(0.009)	(0.008)	(0.008)
50th	-0.231****	-0.231****	-0.229****	-0.231****
	(0.008)	(0.007)	(0.007)	(0.007)
75th	-0.214****	-0.215****	-0.215****	-0.214****
	(0.010)	(0.010)	(0.009)	(0.009)
99th	-0.190****	-0.193****	-0.196****	-0.190****
	(0.019)	(0.019)	(0.017)	(0.018)

Notes: The table reports the estimated marginal effect of credit constraints on labour productivity at selected percentiles of the regional institutional quality variable. The estimated marginal effects are derived from the interaction terms in Specifications (2), (4), (6) and (8) in Table 3. Bootstrapped standard errors are clustered at the region level and are reported in parentheses.

4.2. Accounting for Firm Size Heterogeneity

Table 5 reports the results of the key explanatory variables for the dynamic investment Equation (1) by accounting for firm size heterogeneity. The comparison of the estimated coefficients of the cash flow variable suggests that the sensitivity of investments-to-cash-flow is higher for smaller than for larger firms. The magnitude of the coefficient of the cash flow variable decreases from about 0.36 for micro firms to about 0.25 for large firms. This result highlights that smaller firms suffer from

[8] Several further analyses have been conducted to test the robustness of the main results obtained for the whole sample of firms. Overall, all exercises fully corroborate the results presented in Sub-section 4.1. A detailed description of the robustness tests and the tables reporting the results are presented in Appendix E (Electronic Supplementary Material).

credit rationing to a greater extent than larger firms – corroborating hypothesis H_3.

Table 5: Dynamic investment equation by size class.

Dependent Variable	$\log(I_{isrct}/Kb_{isrct})$			
Estimation Approach	System GMM			
Size Class	Micro	Small	Medium	Large
	(1)	(2)	(3)	(4)
$\log(I_{isrct-1}/Kb_{isrct-1})$	0.064****	0.102****	0.166****	0.227***
	(0.013)	(0.012)	(0.017)	(0.072)
$\log(CF_{isrct}/Kb_{isrct})$	0.357**	0.334****	0.316****	0.246**
	(0.165)	(0.089)	(0.047)	(0.106)
Firm-Level Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
No. of Observations	19,120	35,416	22,797	7,629
No. of Firms	5,732	9,267	5,629	1,752
Model F Statistic [p-value]	39.71 [0.000]	113.18 [0.000]	31.31 [0.000]	34.53 [0.000]
AR (1) (p-value)	0.000	0.000	0.000	0.000
AR (2) (p-value)	0.604	0.997	0.274	0.104
Hansen J Statistic (p-value)	0.988	0.944	0.770	0.996

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. All specifications include a constant term. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences.

Table 6 complements Table 5 by reporting the results of the key explanatory variables for both the static and dynamic versions of the labor productivity equation. The firm-level investment-to-cash-flow sensitivity variable is derived from the corresponding specifications in Table 5. The static labor productivity Equation (2) is estimated through a two-way FE estimator, while the dynamic labor productivity Equation (4) is estimated through a two-step System GMM estimator that considers both internally-generated instruments and the two external IVs for credit constraints and regional institutional quality. The comparison of the results across the four size classes suggests, first, that the negative and statistically significant association between labor productivity and credit constraints diminishes from about -0.28 for micro firms to about -0.19 for large firms when considering the static equation, while the estimated association diminishes from about -0.26 for micro firms to about -0.21 for large firms when considering the dynamic equation. This result highlights that the negative returns of credit constraints on firms' economic performance are greater for smaller than for larger firms –

corroborating H_4. Second, looking at the direct role played by regional institutional quality, location in a "good" institutional environment matters for firms of all sizes except for large firms. Finally, the estimated coefficient of the interaction term between the variables for firm-level credit constraints and region-level institutional quality is positive and statistically significant for micro-, small-, and medium-sized firms, while it is negligible for large firms – substantiating hypotheses $H_{5(b)}$ and $H_{6(b)}$.

These last results are validated in Table 7, which reports the estimated marginal effect of credit constraints on labor productivity at selected percentiles of the distribution of the regional institutional quality variable. The relationship between labor productivity and credit constraints remains negative at all levels of the regional institutional quality variable, but its magnitude diminishes as the quality of local institutions improves for firms in all size classes. The magnitude of the credit constraints-labor productivity relationship and the moderating role of institutional quality differ, in any case, across size classes. "Good" institutional quality plays a greater role in alleviating the negative returns of credit constraints on firm-level productivity for micro- and small-sized firms than for medium- and large-sized firms. Looking at the results obtained from the two-step System GMM estimation, the negative returns of credit constraints on productivity for the average micro- and small-sized firms located in a region at the bottom of the scale in terms of government quality are almost 32% and 20% higher than for micro- and small-firms in a region at the top of the scale, respectively. By contrast, this difference amounts to only 9% and 8.2% for medium- and large-sized firms, respectively. Overall, the negative returns of credit constraints on productivity are almost three times greater for a micro-firm located in a region with the worst institutional quality than for a large one in a region with the best institutional quality.

Table 6: Investment-to-cash flow sensitivity, labour productivity and regional institutional quality by size class.

Dependent Variable	$\log(LP_{isrct})$							
Size Class	Micro				Small			
Estimation Approach	Two-Way FE		System GMM		Two-Way FE		System GMM	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log(LP_{isrct-1})$	…	…	0.527****	0.467****	…	…	0.335****	0.398****
			(0.050)	(0.053)			(0.051)	(0.052)
Credit $Constraint_{isrct}$	-0.279****	-0.350****	-0.262****	-0.456****	-0.218****	-0.267****	-0.220****	-0.338****
	(0.009)	(0.024)	(0.017)	(0.092)	(0.007)	(0.027)	(0.016)	(0.069)
Institutional $Quality_{rct}$	0.049***	0.281***	0.357***	0.905**	0.187**	0.349***	0.332*	0.421*
	(0.017)	(0.086)	(0.126)	(0.395)	(0.077)	(0.120)	(0.176)	(0.242)
Credit $Constraint_{isrct}$ × Institutional $Quality_{rct}$	…	0.122**	…	0.341**	…	0.080*	…	0.197*
		(0.056)		(0.140)		(0.043)		(0.110)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	…	…	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	…	…	Yes	Yes	…	…	Yes	Yes
Country Fixed Effects	…	…	Yes	Yes	…	…	Yes	Yes
No. of Observations	19,120	19,120	19,120	19,120	35,416	35,416	35,416	35,416
No. of Firms	5,732	5,732	5,732	5,732	9,267	9,267	9,267	9,267
Model F Statistic [p-value]	665.88 [0.000]	666.26 [0.000]	936.70 [0.000]	890.74 [0.000]	459.24 [0.000]	461.62 [0.000]	536.96 [0.000]	2,205.53 [0.000]
R^2	0.70	0.70	…	…	0.60	0.61	…	…
Adjusted R^2	0.57	0.57	…	…	0.46	0.47	…	…
AR (1) (p-value)	…	…	0.000	0.000	…	…	0.000	0.000
AR (2) (p-value)	…	…	0.432	0.654	…	…	0.345	0.762
Hansen J Statistic (p-value)	…	…	0.963	0.995	…	…	0.335	0.647
Internally Generated Instruments	…	…	Yes	Yes	…	…	Yes	Yes
External IV for								
Institutional $Quality_{rct}$	…	…	Yes	Yes	…	…	Yes	Yes
Credit $Constraint_{isrct}$	…	…	Yes	Yes	…	…	Yes	Yes
Average Marginal Effect of Credit $Constraint_{isrct}$	…	-0.280****	…	-0.259****	…	-0.218****	…	-0.218****
		(0.008)		(0.019)		(0.006)		(0.011)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. All specifications estimated through the two-step System GMM estimator include a constant term. LP stands for labour productivity. The labour productivity equations represent the second-step equations of the two-equation system, and the variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equations presented in Table 5. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t - 1$ to $t - 10$. Both external IVs are used only in levels in the two-step System GMM approach.

Table 6 − Continues.

Dependent Variable	$\log(LP_{isrct})$							
Size Class	Medium				Large			
Estimation Approach	Two-Way FE		System GMM		Two-Way FE		System GMM	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
$\log(LP_{isrct-1})$	…	…	0.590****	0.428****	…	…	0.256***	0.574****
			(0.060)	(0.027)			(0.092)	(0.138)
$\text{Credit Constraint}_{isrct}$	-0.197****	-0.209****	-0.215****	-0.281****	-0.189****	-0.260****	-0.208****	-0.258*
	(0.008)	(0.004)	(0.012)	(0.034)	(0.016)	(0.050)	(0.033)	(0.142)
$\text{Institutional Quality}_{rct}$	0.081*	0.116***	0.200*	0.318*	0.091	0.151	0.100	0.050
	(0.043)	(0.043)	(0.119)	(0.172)	(0.106)	(0.183)	(0.305)	(0.291)
$\text{Credit Constraint}_{isrct} \times \text{Institutional Quality}_{rct}$	…	0.017*	…	0.099**	…	0.031	…	0.103
		(0.009)		(0.048)		(0.070)		(0.170)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	…	…	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	…	…	Yes	Yes	…	…	Yes	Yes
Country Fixed Effects	…	…	Yes	Yes	…	…	Yes	Yes
No. of Observations	22,797	22,797	22,797	22,797	7,629	7,629	7,629	7,629
No. of Firms	5,629	5,629	5,629	5,629	1,752	1,752	1,752	1,752
Model F Statistic [p-value]	197.17 [0.000]	191.54 [0.000]	2,651.84 [0.000]	2,574.83 [0.000]	98.66 [0.000]	115.37 [0.000]	1,536.81 [0.000]	2,603.77 [0.000]
R^2	0.60	0.60	…	…	0.60	0.63	…	…
Adjusted R^2	0.47	0.47	…	…	0.48	0.51	…	…
AR (1) (p-value)	…	…	0.000	0.000	…	…	0.008	0.009
AR (2) (p-value)	…	…	0.105	0.238	…	…	0.337	0.152
Hansen J Statistic (p-value)	…	…	0.527	0.410	…	…	0.112	0.162
Internally Generated Instruments	…	…	Yes	Yes	…	…	Yes	Yes
External IV for								
$\text{Institutional Quality}_{rct}$	…	…	Yes	Yes	…	…	Yes	Yes
$\text{Credit Constraint}_{isrct}$	…	…	Yes	Yes	…	…	Yes	Yes
Average Marginal Effect of $\text{Credit Constraint}_{isrct}$	…	-0.197****	…	-0.213****	…	-0.107****	…	-0.183****
		(0.005)		(0.010)		(0.029)		(0.036)

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. All specifications estimated through the two-step System GMM estimator include a constant term. LP stands for labour productivity. The labour productivity equations represent the second-step equations of the two-equation system, and the variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equations presented in Table 5. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t-1$ to $t-10$. Both external IVs are used only in levels in the two-step System GMM approach.

Table 7: Credit constraints, labour productivity and the moderation effect of regional institutional quality by size class.

	Marginal Effect of Credit $\text{Constraint}_{isrct}$ on $\log(LP_{isrct})$							
Size Class	Micro		Small		Medium		Large	
Estimation Approach	Two-Way FE	System GMM	Two-Way FE	System GMM	Two-Way FE	System GMM	Two-Way FE	System GMM
Corresponding Specification in Table 6	(2)	(4)	(6)	(8)	(10)	(12)	(14)	(16)
Percentiles of Institutional Quality_{rct}								
1st	-0.350****	-0.456****	-0.267****	-0.338****	-0.207****	-0.272****	-0.117**	-0.237**
	(0.024)	(0.092)	(0.027)	(0.069)	(0.003)	(0.030)	(0.048)	(0.109)
25th	-0.284****	-0.273****	-0.223****	-0.230****	-0.200****	-0.226****	-0.110****	-0.198****
	(0.006)	(0.022)	(0.007)	(0.014)	(0.004)	(0.012)	(0.017)	(0.051)
50th	-0.277****	-0.253****	-0.218****	-0.218****	-0.198****	-0.214****	-0.106***	-0.177****
	(0.009)	(0.017)	(0.006)	(0.011)	(0.005)	(0.010)	(0.036)	(0.033)
75th	-0.267****	-0.225****	-0.211****	-0.200****	-0.194****	-0.196****	-0.104**	-0.164****
	(0.014)	(0.017)	(0.007)	(0.014)	(0.007)	(0.013)	(0.051)	(0.036)
99th	-0.235****	-0.134***	-0.187****	-0.141***	-0.192****	-0.182****	-0.102*	-0.155****
	(0.029)	(0.045)	(0.017)	(0.043)	(0.008)	(0.018)	(0.062)	(0.045)

Notes: The table reports the estimated marginal effect of credit constraints on labour productivity at selected percentiles of regional institutional quality. The estimated marginal effects are derived from the interaction terms in Specifications (2), (4), (6), (8), (10), (12), (14) and (16) in Table 6. Bootstrapped standard errors are clustered at the region level and are reported in parentheses.

5. CONCLUSIONS

Credit constraints have been deemed for long to be a major obstacle for firms to thrive. Scarce credit and/or difficulties in accessing it limit the potential of firms to develop new ideas, to implement them, and to acquire the resources necessary to comply with changes in demand and grow. Micro- and small-sized firms tend to suffer from credit constraints mainly because of their size, frequent lack of collateral, and high fixed costs for financial institutions to evaluate and service them.

However, the extent to which credit constraints affect firm-level performance, in general, and that of micro- and small-sized firms, in particular, remains poorly understood. There has been no research addressing the extent to which sub-national geographic differences in institutional quality affect firm-level productivity. This paper has addressed these issues from a cross-country perspective looking at European manufacturing firms' labor productivity over the period 2009-2016.

The empirical results indicate that firms in the sample countries suffer from restrictions in the credit market. This is more relevant for smaller than for larger firms. Moreover, credit rationing represents a serious barrier for productivity and, consequently, for the economic dynamism of individual firms, as it harms their capacity to innovate and compete in the market. The damage caused by credit rationing is highly sensitive to firm size. Micro- and small-sized firms are negatively affected by credit constraints to a greater extent than larger firms. On average, our more conservative estimates suggest that the negative impact of credit constraints for micro firms is 1.3 times higher than for large ones. Local institutional quality also emerges as an important factor behind the credit constraints-labor productivity relationship. "Good" local institutions can boost firms' productivity and, to a certain extent, attenuate the negative returns of credit constraints, meaning that firms – in particular, micro firms and SMEs – would be in a better position to exploit and transform the advantages related to inter-firm credit relationships into higher productivity. However, while "good" institutions help mitigate the negative impact of lack of credit, they do not suffice to compensate for the fact that credit constraints remain an important barrier for the economic dynamism of firms, especially of those at the bottom end in terms of size.

Lack of adequate access to credit for firms and, especially, for micro firms and SMEs, represents an important market failure with serious consequences for the economy. Hence, existing schemes aimed at supporting the capacity of commercial banks and other financial institutions to lend to micro firms and SMEs address an important market failure and can make a crucial difference in terms of mobilizing local potential and increasing innovation and productivity. However, in areas with lower institutional quality, incentivizing financial institutions to lend to small firms would, on its own, not do the trick. Weak government quality, pervasive corruption, or low levels of transparency and accountability not only affect the capacity of firms to operate in the market, they also contribute to limit their access to funding, for example by weakening the opportunities for trade credit through production transactions. Measures to facilitate access to credit need to be complemented with interventions to improve institutional quality, as both factors together are far more effective in reducing the negative returns of credit constraints and improving the productivity and competitiveness of European firms.

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Electronic Supplementary Material

Appendix A – Descriptive Statistics of the Firm-Level Dataset

The final, cleaned firm-level dataset includes 22,380 manufacturing firms, observed over the period 2009-2016, from 11 European countries – namely, Belgium, Bulgaria, Czech Republic, France, Germany, Hungary, Italy, Portugal, Romania, Slovak Republic and Spain. Table A1 shows that the final sample provides a good representation of the population of manufacturing firms in the 11 European countries considered. As Table A2 indicates, the sample covers all sub-national territories except for the Spanish Canary Islands, due to lack of data. The geographic unit of analysis varies across countries between the levels 1 and 2 of the NUTS regional classification. The reason for this is the need to match the geographic level of disaggregation for the available data on regional institutional quality. Accordingly, NUTS-1 regions are used for Belgium, Germany and Hungary, while NUTS-2 regions are used for the remaining countries.[9] Tables A3 and A4 report the sample distribution by size class and two-digit industrial sector, respectively. The sample includes firms belonging to the four different size classes – micro-, small-, medium- and large-sized firms – and located in all the 11 European countries considered, as well as firms operating in all two-digit manufacturing sectors.

[9] This sub-national classification identifies regions with an effective devolved power to influence the economic performance of local firms in each specific country. It has been frequently used in previous research at both regional (e.g. Rodríguez-Pose and Di Cataldo 2015; Crescenzi et al. 2016; Ketterer and Rodríguez-Pose 2018) and firm level (e.g. Ganau and Rodríguez-Pose 2019).

Table A1: A comparison between the population of manufacturing firms and the sample.

Country	Manufacturing Industry (average 2009-2016)		Sample	
	No.	%	No.	%
Belgium	35,484	2.41	547	2.44
Bulgaria	30,678	2.09	473	2.11
Czech Republic	169,521	11.53	2,611	11.67
France	216,864	14.76	3,341	14.93
Germany	202,874	13.80	2,865	12.80
Hungary	50,068	3.41	771	3.45
Italy	411,203	27.98	6,334	28.30
Portugal	69,246	4.71	1,067	4.77
Romania	48,281	3.29	744	3.32
Slovak Republic	59,397	4.04	915	4.09
Spain	176,030	11.98	2,712	12.12
Total	1,469,646	100.00	22,380	100.00

Notes: Percentage values are defined on column totals. Official country-level data are drawn from the SBS provided by Eurostat.

Table A2: Geographic coverage of the sample.

Country	Regions			
	NUTS Level	In the Country	In the Sample	Percentage Covered
Belgium	1	3	3	100.00
Bulgaria	2	6	6	100.00
Czech Republic	2	8	8	100.00
France	2	22	22	100.00
Germany	1	16	16	100.00
Hungary	1	3	3	100.00
Italy	2	21	21	100.00
Portugal	2	7	7	100.00
Romania	2	8	8	100.00
Slovak Republic	2	4	4	100.00
Spain	2	17	16	94.12
Total		115	114	99.13

Notes: The five French Overseas Departments and the Spanish extra-territorial autonomous cities of Ceuta and Melilla are excluded *à priori* from the analysis, while the Spanish Canary Islands are not included in the analysis due to data unavailability.

Table A3: Sample distribution by country and size class.

Country	Size Classes							
	Micro (≤ 9)		Small (10 - 49)		Medium (50 - 249)		Large (≥ 250)	
	No.	%	No.	%	No.	%	No.	%
Belgium	25	0.44	234	2.53	234	4.16	54	3.08
Bulgaria	92	1.61	258	2.78	105	1.87	18	1.03
Czech Republic	366	6.39	1,010	10.90	884	15.70	351	20.03
France	832	14.52	1,665	17.97	661	11.74	183	10.45
Germany	28	0.49	326	3.52	1,789	31.78	722	41.21
Hungary	22	0.38	160	1.73	447	7.94	142	8.11
Italy	2,555	44.57	3,088	33.32	625	11.10	66	3.77
Portugal	342	5.97	535	5.77	164	2.91	26	1.48
Romania	153	2.67	346	3.73	187	3.32	58	3.31
Slovak Republic	207	3.61	378	4.08	263	4.67	67	3.82
Spain	1,110	19.36	1,267	13.67	270	4.80	65	3.71
Total	5,732	100.00	9,267	100.00	5,629	100.00	1,752	100.00

Notes: Firms are classified according to the average number of employees over the period 2009-2016. The number of employees defining each size class is reported in parentheses.

Table A4: Sample distribution by industrial sector.

NACE Rev. 2 Classification at two-digit level	Firms	
	No.	%
10 - Food products	2,516	11.24
11 – Beverages	447	2.00
12 - Tobacco products	13	0.06
13 – Textiles	607	2.71
14 - Wearing apparel	643	2.87
15 - Leather and related products	500	2.23
16 - Wood, wood and cork's products, except furniture; articles of straw and plaiting materials	879	3.93
17 - Paper and paper products	502	2.24
18 - Printing and reproduction of recorded media	821	3.67
19 - Coke and refined petroleum products	39	0.17
20 - Chemicals and chemical products	892	3.99
21 - Basic pharmaceutical products and pharmaceutical preparations	185	0.83
22 - Rubber and plastic products	1,458	6.51
23 - Other non-metallic mineral products	1,003	4.48
24 - Basic metals	488	2.18
25 - Fabricated metal products, except machinery and equipment	4,438	19.83
26 - Computer, electronic and optical products	749	3.35
27 - Electrical equipment	838	3.74
28 - Machinery and equipment N.E.C.	2,282	10.20
29 - Motor vehicles, trailers and semi-trailers	539	2.41
30 - Other transport equipment	209	0.93
31 – Furniture	605	2.70
32 - Other manufacturing	662	2.96
33 - Repair and installation of machinery and equipment	1,065	4.76
Total	22,380	100.00

Appendix B – Computation of Firm-Level Variables for Investment and Capital Stock

The dependent variable of the first-step dynamic investment Equation (1) – see Sub-section 3.2 in the Manuscript – captures the firm-level real investments in tangible fixed assets (I_{isrct}) scaled by the beginning of the period capital stock (Kb_{isrct}) – with i denoting the firm, s denoting the two-digit industrial sector, r denoting the region of location, c denoting the country of location, and t denoting the year of observation.

Real investments in tangible fixed assets (I_{isrct}) are defined as follows:

$$I_{isrct} = (K^{BV}_{isrct} - K^{BV}_{isrct-1} + Depreciation^{BV}_{isrct})/P_{sct} \tag{B1}$$

where the term K^{BV}_{isrct} denotes the book value (BV) of tangible fixed assets, the term $Depreciation^{BV}_{isrct}$ represents the book value of depreciations, and the term P_{sct} conveys a sector- and country-specific investments price deflator provided by Eurostat.

The capital stock of a firm at the beginning of the period t is defined as the difference between capital stock at the end of period t (K_{isrct}) and capital expenditure in period t, with capital stock defined using the Perpetual Inventory Method as follows:

$$K_{isrct} = K_{isrct-1}(1 - \delta_{isrct}) + I_{isrct}$$
$$\delta_{isrct} = Depreciation^{BV}_{isrct}/K^{BV}_{isrct-1} \tag{B2}$$

where δ_{isrct} represents the depreciation rate, and $K_{isrct-1} = (K^{BV}_{isrc0}/P_{sc0})$ with $t = 0$ for the first observational period t of a firm in the sample.

Appendix C – Definition, Descriptive Statistics and Correlation Matrix of Main Variables

Table C1 reports the definition of the variables entering the investment and labour productivity equations – see Sub-section 3.2 in the Manuscript.

Tables C2 and C3 report some descriptive statistics of the dependent variable and explanatory variables and the correlation matrix of the explanatory variables, respectively, entering the first-step investment equation – see Sub-section 3.2 in the Manuscript.

Tables C4 and C5 report some descriptive statistics of the dependent variable and explanatory variables, and the correlation matrix of the explanatory variables, respectively, entering the second step labour productivity equation – see Sub-section 3.2 in the Manuscript.

Table C1: Definition of the firm- and region-level variables.

Variable	Definition
Firm-Level	
$\mathrm{I}_{\mathrm{isrct}}/\mathrm{Kb}_{\mathrm{isrct}}$	Scaled investments computed as the ratio between real investments in tangible fixed assets and capital stock at the beginning of the period
$\mathrm{Kb}_{\mathrm{isrct}}$	Capital stock at the beginning of the period t defined as the difference between capital stock at the end of the period t (K_{isrct}) and capital expenditure in the period t
$\mathrm{K}_{\mathrm{isrct}}$	Capital stock defined using the Perpetual Inventory Method
$\mathrm{CF}_{\mathrm{isrct}}/\mathrm{Kb}_{\mathrm{isrct}}$	Scaled cash flow computed as the ratio between cash flow and capital stock at the beginning of the period
$\mathrm{CF}_{\mathrm{isrct}}$	Cash flow defined as net income plus annual depreciations
$\mathrm{LP}_{\mathrm{isrct}}$	Labour productivity defined as deflated value added (VA_{isrct}) over employment
$\mathrm{VA}_{\mathrm{isrct}}$	Value added defined as net income plus taxation, plus cost of employees, plus depreciations, plus interests paid
$\mathrm{Sales}_{\mathrm{isrct}}$	Sales representing total turnover
$\Delta\mathrm{Sales}_{\mathrm{isrct}}$	Change in sales between periods t and $t-1$
$\mathrm{Size}_{\mathrm{isrct}}$	Size defined as number of employees
$\Delta\mathrm{Size}_{\mathrm{isrct}}$	Change in number of employees between periods t and $t-1$
$\mathrm{Age}_{\mathrm{isrct}}$	Age defined as year of observation minus the year of a firm's incorporation
$\mathrm{K}_{\mathrm{isrct}}/\mathrm{Employment}_{\mathrm{isrct}}$	Capital-to-employment ratio, where K_{isrct} denotes capital stock
$\mathrm{Credit\ Constraint}_{\mathrm{isrct}}$	Investment-to-cash flow sensitivity estimated from an ECM-type dynamic investment equation
Region-Level	
$\mathrm{Institutional\ Quality}_{\mathrm{rct}}$	Index of regional institutional quality
$\mathrm{Population}_{\mathrm{rct}}$	Population (number of individuals)
$\mathrm{GDP}_{\mathrm{rct}}$	Gross Domestic Product (Euro, millions, constant prices)
$\mathrm{HC}_{\mathrm{rct}}$	Human capital defined as percentage of population aged 25-64 years with tertiary education
$\mathrm{UR}_{\mathrm{rct}}$	Unemployment rate defined as percentage of unemployed population aged 15-74 years

Table C2: Descriptive statistics of the variables entering the investment equation.

Investment Equation				
Dependent Variable	Mean	Std. Dev.	Min.	Max.
$\log(I_{isrct}/Kb_{isrct})$	-2.05	1.48	-17.48	5.29
Explanatory Variables				
$\log(I_{isrct-1}/Kb_{isrct-1})$	-1.94	1.54	-17.48	8.83
$\log(CF_{isrct}/Kb_{isrct})$	-1.04	1.08	-10.55	6.94
$\Delta Sales_{isrct}$	0.04	0.23	-10.66	7.55
$\log(K_{isrct-1}) - \log(Sales_{isrct-1})$	-5.02	1.84	-14.82	4.22
$\log(Size_{isrct})$	3.43	1.51	0.00	9.93
$\log(Age_{isrct})$	2.89	0.74	0.69	6.46
$\log(LP_{isrct-1})$	10.63	0.80	7.17	15.58

Notes: Statistics refer to a sample of 84,962 firm-year observations. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; K stands for capital stock; LP stands for labour productivity.

Table C3: Correlation matrix of the explanatory variables entering the investment equation.

		Investment Equation						
		[1]	[2]	[3]	[4]	[5]	[6]	[7]
$\log(I_{isrct-1}/Kb_{isrct-1})$	[1]	1						
$\log(CF_{isrct}/Kb_{isrct})$	[2]	0.235	1					
$\Delta Sales_{isrct}$	[3]	0.045	0.161	1				
$\log(K_{isrct-1}) - \log(Sales_{isrct-1})$	[4]	-0.188	-0.387	0.043	1			
$\log(Size_{isrct})$	[5]	0.079	0.000	0.023	-0.793	1		
$\log(Age_{isrct})$	[6]	-0.103	-0.080	-0.065	-0.235	0.308	1	
$\log(LP_{isrct-1})$	[7]	0.039	0.196	-0.079	-0.129	0.061	0.273	1

Notes: Correlation coefficients refer to a sample of 84,962 firm-year observations. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; K stands for capital stock; LP stands for labour productivity.

Table C4: Descriptive statistics of the variables entering the labour productivity equation.

Labour Productivity Equation				
Dependent Variable	Mean	Std. Dev.	Min.	Max.
$\log(LP_{isrct})$	10.65	0.79	5.85	15.58
Explanatory Variables				
$\log(K_{isrct}/Employment_{isrct})$	10.32	1.17	2.72	16.32
$\log(Size_{isrct})$	3.43	1.51	0.00	9.93
$\Delta Size_{isrct}$	0.02	0.19	-2.20	2.20
$\log(Sales_{isrct})$	15.28	1.83	5.30	24.73
$\log(Age_{isrct})$	2.89	0.74	0.69	6.46
$\text{Institutional Quality}_{rct}$	0.63	0.20	0	1
$\log(Population_{rct})$	15.09	0.81	11.75	16.70
$\log(GDP_{rct}/Population_{rct})$	10.03	0.52	8.08	11.05
$\log[HC_{rct}/(1-HC_{rct})]$	-1.21	0.47	-2.31	-0.06
$\log[UR_{rct}/(1-UR_{rct})]$	-2.32	0.59	-3.79	-0.57

Notes: Statistics refer to a sample of 84,962 firm-year observations. LP stands for labour productivity; K stands for capital stock; GDP stands for Gross Domestic Product; HC stands for human capital, defined as percentage of population aged 25-64 with tertiary education; UR stands for unemployment rate.

Table C5: Correlation matrix of the explanatory variables entering the labour productivity equation.

		Labour Productivity Equation									
		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
$\log(K_{isrct}/Employment_{isrct})$	[1]	1									
$\log(Size_{isrct})$	[2]	0.050	1								
$\Delta Size_{isrct}$	[3]	-0.065	0.050	1							
$\log(Sales_{isrct})$	[4]	0.321	0.847	0.012	1						
$\log(Age_{isrct})$	[5]	0.201	0.308	-0.080	0.369	1					
Institutional $Quality_{rct}$	[6]	0.120	0.241	-0.028	0.388	0.269	1				
$\log(Population_{rct})$	[7]	0.135	0.047	-0.010	0.219	0.231	0.219	1			
$\log(GDP_{rct}/Population_{rct})$	[8]	0.245	-0.028	-0.032	0.266	0.256	0.563	0.541	1		
$\log[HC_{rct}/(1-HC_{rct})]$	[9]	0.030	0.126	-0.021	0.204	0.182	0.444	0.158	0.402	1	
$\log[UR_{rct}/(1-UR_{rct})]$	[10]	-0.026	-0.349	-0.001	-0.345	-0.137	-0.362	-0.123	-0.239	0.058	1

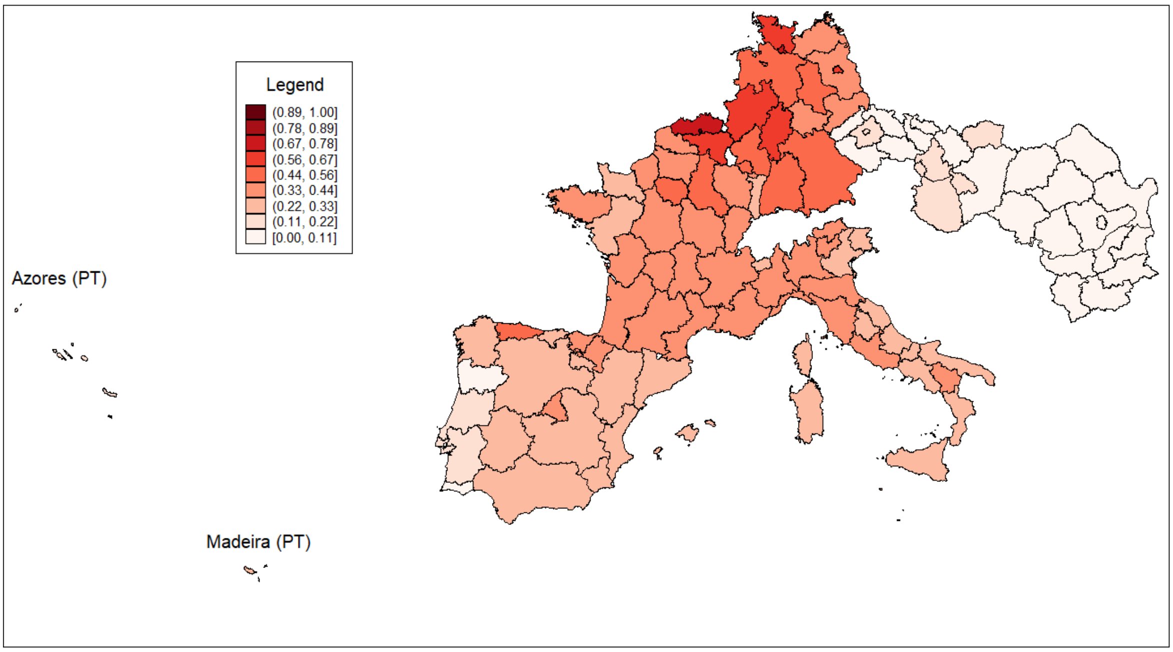
Notes: Correlation coefficients refer to a sample of 84,962 firm-year observations. K stands for capital stock; GDP stands for Gross Domestic Product; HC stands for human capital, defined as percentage of population aged 25-64 with tertiary education; UR stands for unemployment rate.

Appendix D – Spatial Distribution of the Main Variables for Labour Productivity, Investment-to-Cash Flow Sensitivity and Regional Institutional Quality

Figure D1 maps the spatial distribution of the regional average firm-level labour productivity over the period 2009-2016. Three groups of regions can be identified. The first group, consisting mainly of German and Belgian regions, is characterized by the presence of high-productivity firms. The second group spans across France and Northern Italy, and is dominated by mid-level productivity firms. The third group of regions has, on average, low-level productivity firms, and is mainly found in Portugal, Spain, Bulgaria, Hungary, Romania and the Slovak Republic.

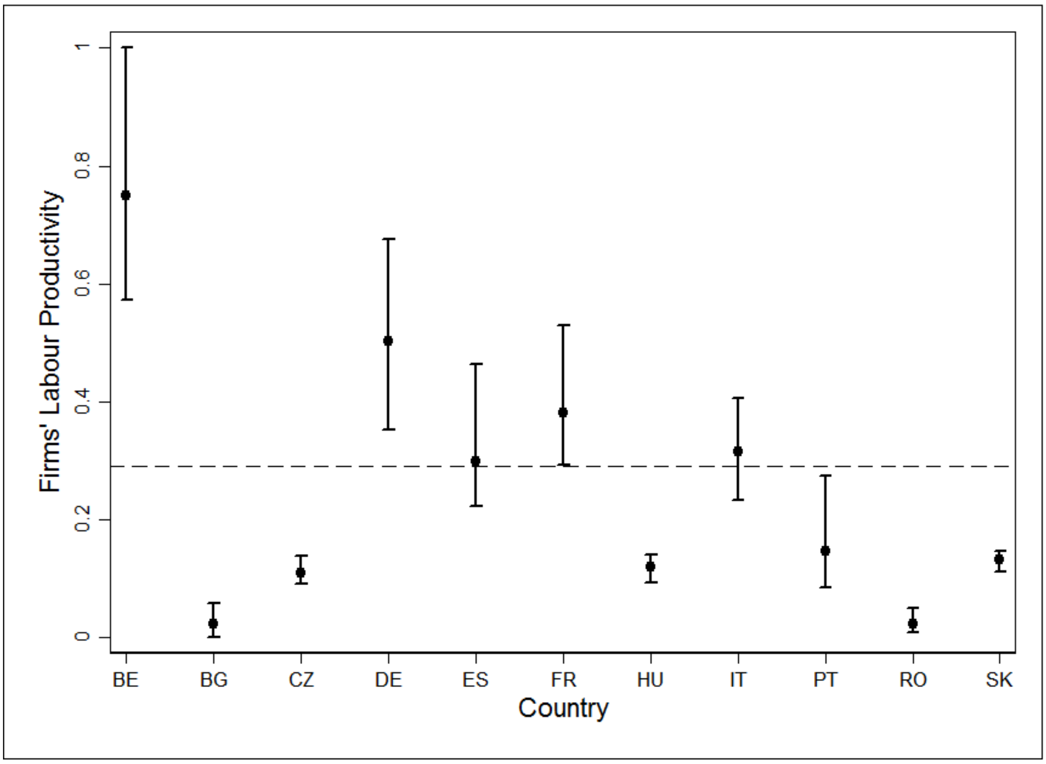
Figure D2 depicts the within-country variability of the regional average firm-level labour productivity. Within-country regional variability in productivity is much higher in Belgium, Germany, Spain, France, Italy and Portugal than in the former communist countries of the EU included in the analysis. In the latter, productivity tends to be uniformly low across all regions. Firm-level labour productivity is only clearly above the average of the sample in Belgium, Germany and France, while in Spain and Italy regions with above average firm-level productivity coexist with low-productivity regions.

Figure D1: Spatial distribution of regional average firm-level labour productivity.



Notes: Yearly firm-level labour productivity − defined as deflated value added over employment − has been averaged first at the regional level, and then over the period 2009-2016. Finally, the time-averaged regional measure has been standardized in the interval [0,1]. The higher the value of the index, i.e. the more productive on average the firms in a region, the darker the shade.

Figure D2: Within-country variability of regional average firm-level labour productivity.



Notes: Yearly firm-level labour productivity − defined as deflated value added over employment − has been averaged first at the regional level, and then over the period 2009-2016. Finally, the time-averaged regional measure has been standardized in the interval [0,1]. The dashed line refers to the sample average, while the dots refer to country-level mean values.

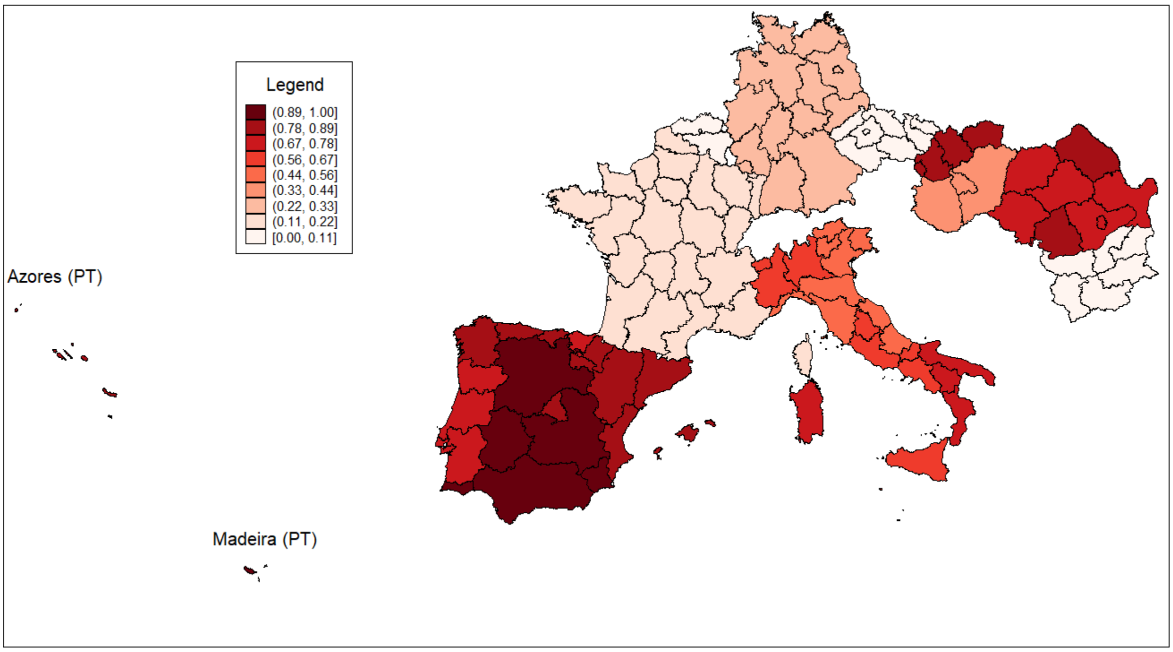
Figure D3 maps the spatial distribution of the regional average firm-level estimated investment-to-cash flow sensitivity. In this exercise firm-level investment-to-cash flow sensitivity has been estimated using a Pooled Ordinary Least Squares (OLS) approach on a simple linear regression of scaled real investments in tangible fixed assets on scaled cash flow.[10] Looking at the map, investment-to-cash-flow sensitivity emerges more as a national rather than a regional phenomenon. Belgium, Germany and France show very low values of the estimated elasticity – signaling that constraints to credit for firms in these countries are, on average, relatively low –, while Spain, Portugal, Romania and the Slovak Republic display very high values of the average estimated investment-to-cash-flow sensitivity. However, as Figure D4 shows, a deeper look at the within-country variability of the regional average firm-level investment-to-cash flow sensitivity highlights the presence of two groups of countries. The first group, including Belgium, Bulgaria, Czech Republic, France, Hungary and the Slovak Republic, presents limited − or almost absent − heterogeneity across regions. The remaining countries, by contrast, exhibit much higher cross-regional variations of the average firm-level investment-to-cash flow sensitivity − this is the case, in particular, for Germany, Italy, Portugal, Romania and Spain. Although, at first sight, this may indicate that more centralized countries (with the exception of Belgium) are more prone to having similar access to credit across their whole territory than more decentralized ones (bar Portugal), greater research is needed in order to explain within country differences in access to credit.

[10] The estimated static investment equation can be specified as follows:

$$\log(I_{isrct}/Kb_{isrct}) = \alpha_0 + \alpha_1 \log(CF_{isrct}/Kb_{isrct}) + \varepsilon_{isrct}$$

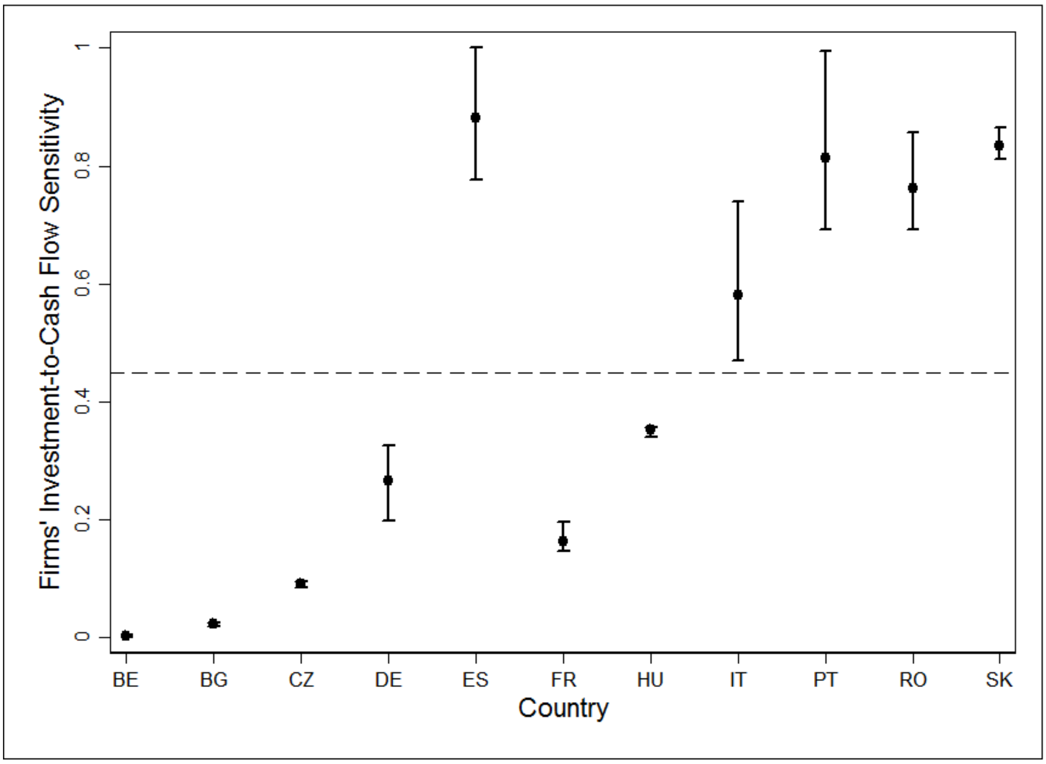
and has been estimated by correcting standard errors for heteroskedasticity.

Figure D3: Spatial distribution of regional average firm-level investment-to-cash flow sensitivity.



Notes: Firm-level investment-to-cash flow sensitivity has been estimated via Pooled OLS with robust standard errors − the null hypothesis of homoscedasticity is rejected with p-value equal to 0.000. Firm-level estimated elasticities have been averaged at the regional level, and then over the period 2009-2016. Finally, the time-averaged region-specific investment-to-cash flow sensitivity measure has been standardized in the interval [0,1]. The higher the value of the measure, i.e. the higher the average firms' investment-to-cash flow sensitivity, the darker the shade.

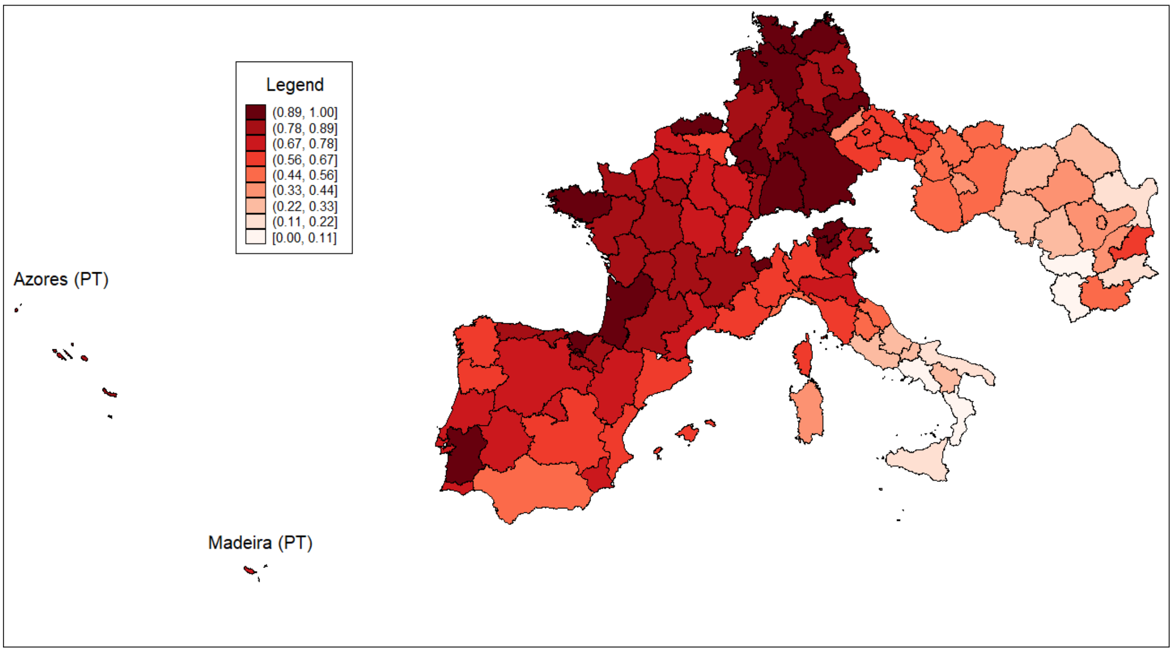
Figure D4: Within-country regional variability of firms' investment-to-cash flow sensitivity.



Notes: Firm-level investment-to-cash flow sensitivity has been estimated via Pooled OLS with robust standard errors − the null hypothesis of homoscedasticity is rejected with p-value equal to 0.000. Firm-level estimated elasticities have been averaged at the regional level, and then over the period 2009-2016. Finally, the time-averaged region-specific investment-to-cash flow sensitivity measure has been standardized in the interval [0,1]. The dashed line refers to the sample average, while the dots refer to country-level mean values.

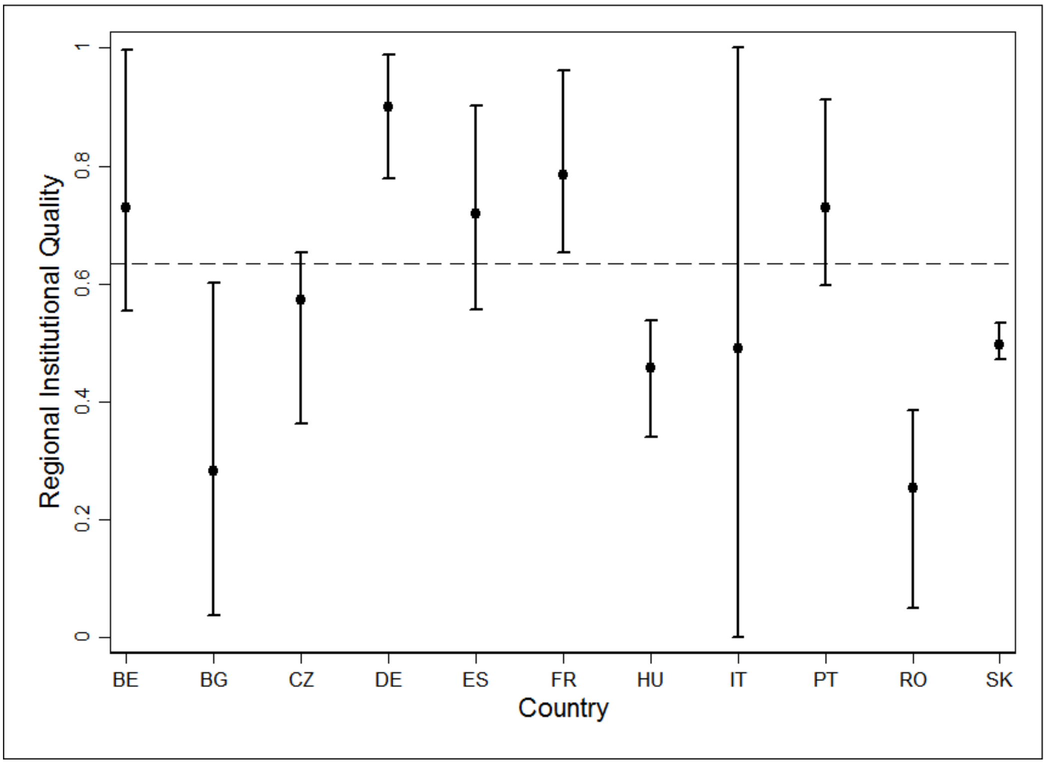
Figure D5 maps the spatial distribution of the regional institutional quality index and shows the existence of remarkable differences in institutional quality both within and across countries. Germany and Italy, for example, represent the two extremes. On the one hand, German regions have, on average, the best institutional quality in the sample, while, at the same time, revealing limited internal variation in what is a relatively homogeneous within-country structure. On the other hand, Italy has, on average, a low quality of regional institutions and internal heterogeneity is rather marked. Figure D6 complements Figure D5 by plotting the within-country variations of the regional institutional quality index. German and French regions all hover above the sample mean, while Bulgarian, Hungarian, Romanian and Slovak regions are all located below the sample mean. Italy shows the highest within-country variability in institutional quality, followed by Bulgaria and Belgium.

Figure D5: Spatial distribution of the institutional quality index.



Notes: The non-standardized yearly institutional quality index has been averaged over the period 2009-2016, and then standardized in the interval [0,1]. The higher the value of the index, i.e. the better the institutional quality in a region, the darker the shade.

Figure D6: Within-country variability of the institutional quality index.



Notes: The non-standardized yearly institutional quality index has been averaged over the period 2009-2016, and then standardized in the interval [0,1]. The dashed line refers to the sample average, while the dots refer to country-level mean values.

Appendix E - Robustness Tests

The robustness of the main results obtained for the whole sample of firms has been tested, first, by considering an alternative specification of the first-step dynamic investment equation. Specifically, Equation (1) – see Sub-section 3.2 in the Manuscript – has been modified in order to make it closer to the ECM specification proposed by Bond et al. (2003).[11] In particular, Equation (1) has been modified by adding to its right-hand side the first-order time-lagged variables for scaled cash flow ($CF_{isrct-1}/Kb_{isrct-1}$) and change in sales ($\Delta Sales_{isrct-1}$), and by replacing the first-order time lag of the error correction term with its second-order time lag. Differently from the specification proposed by Bond et al. (2003), the modified version of Equation (1) still controls for the firm-level variables capturing age, size, and lagged labour productivity. The abovementioned changes to Equation (1) lead to specify the following alternative dynamic investment equation:

$$\log\left(\frac{I_{isrct}}{Kb_{isrct}}\right) = \alpha_0 + \alpha_1 \log\left(\frac{I_{isrct-1}}{Kb_{isrct-1}}\right) + \alpha_2 \log\left(\frac{CF_{isrct}}{Kb_{isrct}}\right) + \alpha_3 \log\left(\frac{CF_{isrct-1}}{Kb_{isrct-1}}\right)$$

$$+\alpha_4 \Delta Sales_{isrct} + \alpha_5 \Delta Sales_{isrct-1} + \alpha_6[\log(K_{isrct-2}) - \log(Sales_{isrct-2})]$$

$$+\alpha_7 \log(LP_{isrct-1}) + \alpha_8 \log(Age_{isrct}) + \alpha_9 \log(Size_{isrct}) + \varepsilon_{isrct}$$

$$\varepsilon_{isrct} = v_i + v_s + v_c + v_t + v_{isrct} \qquad \text{(E1)}$$

where all terms are defined as for Equation (1) in the Manuscript. Equation (E1) is estimated through the two-step System GMM estimator. The variables capturing firm age, as well as sector, country, and time fixed effects, are treated as exogenous, and are used as instruments for themselves only in levels. All the other explanatory variables are treated as endogenous and are instrumented using their second- and third-order lagged levels in the differenced equation, and their second- and third-order lagged differences in the level equation. It is worth noting that the inclusion of a second-order time lagged variable causes a reduction in the number of observations, that diminishes from 84,962 to

[11] We thank one anonymous Referee for having inspired this robustness test.

62,582.

Table E1 reports the results of the key coefficients obtained through the two-step System GMM estimation of Equation (E1), as well as those obtained from the estimation of the static and dynamic versions of the second-step labour productivity equation – see Equations (2) and (4) in Sub-sections 3.2 and 3.3, respectively, in the Manuscript. It is worth underlining that the variable for credit constraints included in the right-hand side of the productivity equation in this robustness exercise represents the investment-to-cash flow sensitivity measure obtained from the estimation of the first-step dynamic investment Equation (E1). The results reported in Table E1 confirm those presented in the Manuscript. First, the coefficient of the cash flow variable is positive and statistically significant, thus suggesting evidence of firms facing restrictions in accessing external financial resources. Second, looking at the productivity equation, the results highlight the existence of a negative credit constraints-labour productivity association, as well as that regional institutional quality is in a positive direct association with firm-level labour productivity. Finally, the positive coefficient of the interaction term between the variables for credit constraints and regional institutional quality confirms the role played by 'good' institutions in alleviating the negative returns of credit rationing on firms' labour productivity.

Table E1: Robustness test using an alternative specification of the dynamic investment equation.

Dependent Variable	$\log(I_{isrct}/Kb_{isrct})$	$\log(LP_{isrct})$			
Estimation Approach	System GMM	Two-Way FE		System GMM	
	(1)	(2)	(3)	(4)	(5)
$\log(I_{isrct-1}/Kb_{isrct-1})$	0.111****	…	…	…	…
	(0.019)				
$\log(CF_{isrct}/Kb_{isrct})$	1.272****	…	…	…	…
	(0.118)				
$\log(LP_{isrct-1})$	0.368****	…	…	0.262****	0.338****
	(0.087)			(0.026)	(0.038)
$\text{Credit Constraint}_{isrct}$	…	-0.335****	-0.474****	-0.228****	-0.693****
		(0.012)	(0.040)	(0.021)	(0.138)
$\text{Institutional Quality}_{rct}$	…	0.120**	0.283**	0.270**	0.343***
		(0.060)	(0.126)	(0.132)	(0.124)
$\text{Credit Constraint}_{isrct} \times \text{Institutional Quality}_{rct}$	…	…	0.092*	…	0.324***
			(0.054)		(0.117)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	…	Yes	Yes	Yes	Yes
Firm Fixed Effects	…	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	…	…	Yes	Yes
Country Fixed Effects	Yes	…	…	Yes	Yes
No. of Observations	62,582	62,582	62,582	62,582	62,582
No. of Firms	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	55.32 [0.000]	673.89 [0.000]	355.42 [0.000]	638.90 [0.000]	636.06 [0.000]
R^2	…	0.56	0.45	…	…
Adjusted R^2	…	0.56	0.45	…	…
AR (1) (p-value)	0.000	…	…	0.000	0.000
AR (2) (p-value)	0.847	…	…	0.300	0.155
Hansen J Statistic (p-value)	0.413	…	…	0.307	0.308
Internally Generated Instruments	Yes	…	…	Yes	Yes
External IV for					
$\text{Institutional Quality}_{rct}$	…	…	…	Yes	Yes
$\text{Credit Constraint}_{isrct}$	…	…	…	Yes	Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. Specifications (1), (4) and (5) include a constant term. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; LP stands for labour productivity. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equation presented in Specification (1). The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t-1$ to $t-10$. Both external IVs are used only in levels in the two-step System GMM approach.

The second robustness exercise focuses on the second-step labour productivity equation. Specifically, it considers two measures for firm-level productivity alternative to the value added-based labour productivity variable. First, following Chen and Guariglia (2013), labour productivity is defined as sales (rather than value added) over employment (LP^{*}_{isrct}). Second, labour productivity is replaced by a measure of Total Factor Productivity (TFP_{isrct}), which is defined as the residual of a Cobb-Douglas production function, and is estimated through the approach proposed by Ackerberg et al. (2015).[12]

Table E2 reports the results obtained when considering the sales-based labour productivity variable. It is worth underlining that the first-step dynamic investment equation used to retrieve the investment-to-cash flow sensitivity measure corresponds to Equation (1) in the Manuscript – see Sub-section 3.2 – with the only exception that the control variable for lagged labour productivity is now defined in terms of sales rather than value added. Moreover, the second-step static and dynamic labour productivity equations correspond to Equations (2) and (4) in the Manuscript – see Sub-sections 3.2 and 3.3 –, with the only exception that the control variable for sales originally included in the models is now excluded to avoid spurious correlations – in fact, the dependent variable used in this robustness exercise is defined in terms of sales. Overall, the results confirm those presented in the Manuscript. First, looking at the investment equation, the coefficient of the cash flow variable is positive and statistically significant. Second, looking at the productivity equation, the results confirm a negative credit constraints-labour productivity association, as well as a positive direct association between regional institutional quality firms' labour productivity. Finally, the positive coefficient of the interaction term between the variables for credit constraints and regional institutional quality confirms the role played by high-quality institutions in alleviating the negative returns of credit rationing on firm-level labour productivity.

[12] Specifically, Total Factor Productivity is estimated considering value added as output variable, capital stock as state variable, labour cost as free variable, and, in the spirit of Olley and Pakes (1996), investment as proxy variable to control for the correlation between unobservable productivity shocks and input levels. Although Levinsohn and Petrin (2003) have suggested to use intermediate inputs rather than investment as a proxy variable, our data present an extremely large number of missing values on intermediate inputs figures.

Table E2: Robustness test using a sales-based measure of labour productivity.

Dependent Variable	$\log(I_{isrct}/Kb_{isrct})$	$\log(LP^*_{isrct})$			
Estimation Approach	System GMM	Two-Way FE		System GMM	
	(1)	(2)	(3)	(4)	(5)
$\log(I_{isrct-1}/Kb_{isrct-1})$	0.113****	…	…	…	…
	(0.012)				
$\log(CF_{isrct}/Kb_{isrct})$	0.889****	…	…	…	…
	(0.090)				
$\log(LP^*_{isrct-1})$	0.135***	…	…	0.728****	0.735****
	(0.132)			(0.038)	(0.033)
$\text{Credit Constraint}_{isrct}$	…	-0.407****	-0.483****	-0.334****	-0.418****
		(0.019)	(0.024)	(0.022)	(0.077)
$\text{Institutional Quality}_{rct}$	…	0.052*	0.116***	0.116**	0.211**
		(0.029)	(0.041)	(0.058)	(0.106)
$\text{Credit Constraint}_{isrct} \times \text{Institutional Quality}_{rct}$	…	…	0.084****	…	0.226**
			(0.010)		(0.113)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	…	Yes	Yes	Yes	Yes
Firm Fixed Effects	…	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	…	…	Yes	Yes
Country Fixed Effects	Yes	…	…	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	54.25 [0.000]	106.40 [0.000]	104.83 [0.000]	2,368.17 [0.000]	3,069.79 [0.000]
R^2	…	0.13	0.13	…	…
Adjusted R^2	…	0.13	0.13	…	…
AR (1) (p-value)	0.000	…	…	0.000	0.000
AR (2) (p-value)	0.385	…	…	0.638	0.612
Hansen J Statistic (p-value)	0.599	…	…	0.118	0.646
Internally Generated Instruments	Yes	…	…	Yes	Yes
External IV for					
$\text{Institutional Quality}_{rct}$	…	…	…	Yes	Yes
$\text{Credit Constraint}_{isrct}$	…	…	…	Yes	Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. Specifications (1), (4) and (5) include a constant term. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; LP^* stands for sales-based labour productivity. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equation presented in Specification (1). The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t - 1$ to $t - 10$. Both external IVs are used only in levels in the two-step System GMM approach.

Table E3 reports the results obtained when considering Total Factor Productivity as dependent variable. Similarly to the previous case, the first-step dynamic investment equation used to retrieve the investment-to-cash flow sensitivity measure corresponds to Equation (1) in the Manuscript – see Sub-section 3.2 – with the only exception that the control variable for lagged labour productivity is now replaced by lagged Total Factor Productivity. The second-step static and dynamic labour productivity equations correspond to Equations (2) and (4) in the Manuscript – see Sub-sections 3.2 and 3.3. Once again, the results presented in the Manuscript are fully confirmed. The first-step investment equation highlights a positive association between real investments and cash flow. Looking at the productivity equation, the results based on a Total Factor Productivity measure fully confirm those concerning labour productivity. First, it emerges a negative credit constraints-productivity association. Second, regional institutional quality is positively associated with firms' productivity. Finally, it is also confirmed the positive moderation role played by institutional quality on the credit constraints-productivity relationship.

Table E3: Robustness test using a measure of TFP.

Dependent Variable	$\log(I_{isrct}/Kb_{isrct})$	$\log(TFP_{isrct})$			
Estimation Approach	System GMM	Two-Way FE		System GMM	
	(1)	(2)	(3)	(4)	(5)
$\log(I_{isrct-1}/Kb_{isrct-1})$	0.096****	…	…	…	…
	(0.010)				
$\log(CF_{isrct}/Kb_{isrct})$	0.601****	…	…	…	…
	(0.077)				
$\log(TFP_{isrct-1})$	0.009****	…	…	0.778****	0.858****
	(0.001)			(0.047)	(0.043)
$\text{Credit Constraint}_{isrct}$	…	-0.037****	-0.110***	-0.045***	-0.091****
		(0.006)	(0.037)	(0.016)	(0.025)
$\text{Institutional Quality}_{rct}$	…	0.511*	0.666*	0.036*	0.172****
		(0.306)	(0.344)	(0.021)	(0.049)
$\text{Credit Constraint}_{isrct} \times \text{Institutional Quality}_{rct}$	…	…	0.123**	…	0.077***
			(0.055)		(0.026)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes
Region-Level Controls	…	Yes	Yes	Yes	Yes
Firm Fixed Effects	…	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	Yes	…	…	Yes	Yes
Country Fixed Effects	Yes	…	…	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	54.87 [0.000]	379.35 [0.000]	369.80 [0.000]	3,444.48 [0.000]	3,850.10 [0.000]
R^2	…	0.42	0.42	…	…
Adjusted R^2	…	0.42	0.42	…	…
AR (1) (p-value)	0.000	…	…	0.000	0.000
AR (2) (p-value)	0.755	…	…	0.394	0.362
Hansen J Statistic (p-value)	0.334	…	…	0.943	0.903
Internally Generated Instruments	Yes	…	…	Yes	Yes
External IV for					
$\text{Institutional Quality}_{rct}$	…	…	…	Yes	Yes
$\text{Credit Constraint}_{isrct}$	…	…	…	Yes	Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Bootstrapped standard errors are clustered at the region level and are reported in parentheses. Specifications (1), (4) and (5) include a constant term. I stands for real investments in tangible fixed assets; Kb stands for capital stock at the beginning of the period; CF stands for cash flow; TFP stands for Total Factor Productivity. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The variable $Credit\ Constraint_{isrct}$ is the estimated firm-level investment-to-cash flow sensitivity from the first-step dynamic investment equation presented in Specification (1). The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the credit constraint variable is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t-1$ to $t-10$. Both external IVs are used only in levels in the two-step System GMM approach.

The third (and final) robustness exercise is designed as a test of the empirical modelling adopted in the paper. It consists in bypassing the two-equation system given by a first-step investment equation – used to both infer on the credit constraints condition of firms, and retrieve the investment-to-cash flow sensitivity measure employed as a proxy for credit constraints – and a second-step labour productivity equation, and in adopting a 'direct' approach where a firm-level measure of internal financial dependence is included directly in the labour productivity equation as explanatory variable.[13] This exercise aims at testing the robustness of the main results in light of the critique that the investment-to-cash flow sensitivity measure is a weak proxy for credit constraints (Kaplan and Zingales 1997).

This exercise is poorly based on the work by Rajan and Zingales (1998), who suggest that external financial dependence is positively correlated with productivity. Specifically, Rajan and Zingales (1998) consider a country- and industry-specific measure of external financial dependence constructed by aggregating firms' balance sheet figures and defined as capital expenditure minus cash flow divided by capital expenditure. Essentially, this measure proxies for the share of capital investments realized using external financial resources. The existence of a positive association between the use of external finance and productivity is confirmed also at the firm level. Among the most recent contributions, both Levine and Warusawitharana (2019) and Franklin et al. (2020) find a positive effect of debt growth on productivity growth.

Drawing on this rationale, this robustness exercise consists in estimating the static and dynamic versions of the labour productivity equation by replacing the estimated investment-to-cash flow measure – that was obtained by a first-step investment equation – with a firm-level measure of internal financial dependence. First, firm-level external financial dependence (EFD_{isrct}) is defined as follows:

$$EFD_{isrct} = \left(\frac{I_{isrct} - CF_{isrct}}{I_{isrct}}\right) \quad \text{(E2)}$$

[13] We thank one anonymous Referee for having suggested this exercise.

where I_{isrct} denotes real investments in tangible fixed assets of firm i operating in sector s and located in region r in country c at time t, and CF_{isrct} denotes a firm's cash flow. Subsequently, internal financial dependence (IFD_{isrct}) is defined as $1 - EFD_{isrct}$, and is used as a proxy for the share of investments realized using internally-generated resources. The measure of internal financial dependence is used in place of that of external financial dependence for the sake of consistency with respect to the empirical analysis presented throughout the paper.

In line with the abovementioned contributions, a negative estimated association between internal financial dependence and labour productivity would confirm the intuition of the paper and provide evidence that firms' labour productivity is hampered by credit rationing. Similarly, a positive estimated coefficient of the interaction term between the variables for internal financial dependence and regional institutional quality would provide evidence that 'good' local institutions contribute alleviating the negative productivity returns of credit constraints.

Table E4 reports the results of the key coefficients obtained through the two-way FE (two-step System GMM) estimation of the static (dynamic) labour productivity equation. Overall, the results confirm the intuition and empirical evidence presented in the Manuscript. Looking at Specifications (1) and (3), it emerges, first, that the coefficient of the variable capturing internal financial dependence is negative and statistically significant, and, second, that regional institutional quality is in a positive direct association with firm-level labour productivity. Finally, looking at Specifications (2) and (4), the results highlight a positive and statistically significant coefficient of the interaction term between internal financial dependence and institutional quality, in line with the main results presented in the Manuscript.

Table E4: Robustness test using a measure of internal financial dependence.

Dependent Variable	$\log(LP_{isrct})$			
Estimation Approach	Two-Way FE		System GMM	
	(1)	(2)	(3)	(4)
$\log(LP_{isrct-1})$	…	…	0.142****	0.180****
			(0.035)	(0.038)
IFD_{isrct}	-0.308****	-0.592****	-0.267****	-0.136**
	(0.011)	(0.117)	(0.015)	(0.068)
Institutional $Quality_{rct}$	0.151***	0.318**	0.373*	0.950*
	(0.057)	(0.128)	(0.192)	(0.552)
$IFD_{isrct} \times$ Institutional $Quality_{rct}$	…	0.125****	…	0.260**
		(0.025)		(0.130)
Firm-Level Controls	Yes	Yes	Yes	Yes
Region-Level Controls	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	…	…
Year Fixed Effects	Yes	Yes	Yes	Yes
Two-Digit Sector Fixed Effects	…	…	Yes	Yes
Country Fixed Effects	…	…	Yes	Yes
No. of Observations	84,962	84,962	84,962	84,962
No. of Firms	22,380	22,380	22,380	22,380
Model F Statistic [p-value]	662.37 [0.000]	726.71 [0.000]	875.44 [0.000]	1,990.85 [0.000]
R^2	0.49	0.49	…	…
Adjusted R^2	0.49	0.49	…	…
AR (1) (p-value)	…	…	0.000	0.000
AR (2) (p-value)	…	…	0.833	0.645
Hansen J Statistic (p-value)	…	…	0.138	0.710
Internally Generated Instruments	…	…	Yes	Yes
External IV for				
Institutional $Quality_{rct}$	…	…	Yes	Yes
IFD_{isrct}	…	…	Yes	Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$; **** $p < 0.001$. Standard errors are clustered at the region level and are reported in parentheses. Specifications (3) and (4) include a constant term. LP stands for labour productivity; IFD stands for internal financial dependence. The two-step System GMM estimation treats the age variable and the sets of industrial sector-, country- and time-specific dummies as exogenous, and uses them as instruments for themselves only in levels; all the other variables, instead, are treated as potentially endogenous and instrumented using their second- and third-order lagged values in both levels and first differences. The external IV used to instrument the institutional quality variable is the regional variability in precipitations during the growing season in the pre-industrialization period 1500-1750. The external IV used to instrument the variable IFD is the standard deviation of the country-level bank Z-score defined over a 10-year window over the period $t-1$ to $t-10$. Both external IVs are used only in levels in the two-step System GMM approach.

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