Financial Markets and the Allocation of Capital: The Role of Productivity

February 2020

Abstract

Traditional measures of financial allocative efficiency focus on the Q-theory of investment and, in particular, on the elasticity of firm finance growth to the growth of firm real value added. This paper introduces an alternative measure that focuses instead on firm productivity. The measure is based on a simple theoretical framework that delivers clear predictions on the sign and the size of the elasticity of firm credit growth to current and future productivity growth depending on capital market frictions. When applied to the novel firm-level dataset of the Competitiveness Research Network (CompNet) set up by the EU System of Central Banks, the proposed measure leads to normative statements about the efficiency of credit allocation across the largest Eurozone economies, reversing the conclusions that would be reach through traditional measures.

JEL: G10, G21, G31, D92, F3, O16.
Keywords: Bank Credit, Capital Allocation, Productivity, Credit Constraints.

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Acknowledgments

We thank Craig Brown, Davin Chor, Luigi Guiso, Fabiano Schivardi and seminar participants at the National University of Singapore, ABFER, Graduate Institute Geneva, Oxford, Trinity College Dublin for useful comments and suggestions. We are deeply indebted for access to data and discussion to: Joao Amador, Antoine Berthou, Elena Biewen, Paloma Garcia-Lopez, Jan Hagemejer, Carmen Martinez, Filippo Oropallo, Charlotte Sandoz-dit-Bragard, Nurmi Satu, Ana Cristina Soares, and Vincent Vicard. All remaining errors are ours.

1 Introduction

The efficient allocation of capital is a key element for the success of an economy. In advanced countries outstanding credit to non-financial corporations is about 90% of GDP (Figure 1); clearly the allocation of such a large amount of funds is a first order issue. In fact, one of the main channels through which financial development accelerates economic growth is exactly by improving the allocation of capital. This is a traditional argument that several authors have suggested, including Bagehot (1873), Goldsmith (1969), McKinnon (1973), Shaw (1973), Greenwood and Jovanovic (1990), Beck et al. (2000), and Levine (2005).

There is an extensive literature on the theoretical mechanisms through which financial markets improve capital allocation (see Levine (2005) for a review). Earlier works on these issues include, among others, Boyd and Prescott (1986) who show that financial intermediaries reduce the costs of acquiring information about firms, managers and market conditions, reducing the asymmetries between lenders and borrowers, thereby improving resource allocation. Whereas, Stiglitz and Weiss (1983) and Jensen (1986) argue that, to the extent that providers of capital can monitor firms, this will make managers maximise firm value, improving the efficiency of capital usage. Finally, Boyd and Smith (1992) highlight that financial intermediaries facilitate the pooling of savings, allowing for better exploitation of economies of scale and overcoming investment indivisibilities. This improves resource allocation and boost technological innovation.

However, how can we empirically measure the efficiency of the market in allocating capital? The classical approach is rooted in the Q-theory of investment: efficiency requires financing firms with a market value below the replacement value, as this gap (Tobin's Q) signals that profits are expected to rise. Accordingly, the faster the market can direct funds towards high-Q firms, the higher the efficiency in capital allocation at any point in time. Data limitations, however, typically make Q-theory based measures of efficiency hard to compute for a large set of industries and countries; for this reason, alternative measures have been proposed. Among them, the most influential one is arguably associated with Wurgler (2000) who, in the wake of Hubbard (1998), suggests to use the elasticity of investment growth (proxying growth in financing) to value added growth (proxying growth in investment opportunities). In particular, Wurgler (2000) shows that, for a large sample of countries and industries, value added growth is positively correlated with Tobin's Q. Hence, higher elasticity of investment growth to value added growth can be reliably interpreted as an indicator of better allocative efficiency as funds are more quickly reallocated to sectors offering higher opportunities. This approach has been widely used in the finance literature, including, among others, works by Beck et al. (2007), Hartmann et al. (2007), Morck et al. (2011), and Lee et al. (2016).

A different approach is followed, instead, in the macroeconomic and growth literature, where the efficient allocation of capital has been analysed mainly through the lenses of 'productivity', i.e. value added per factor input rather than value added per se (see, e.g., Hsieh and Klenow, 2009; Gopinath et al., 2017). The underlying idea is that funds are efficiently allocated when their alternative uses generate the same value added for given amounts of factor inputs, or equivalently when the value of the marginal productivity of each factor is equalized across alternative uses. Any deviation from equalization is interpreted as a signal of allocative inefficiency, and the speed at which deviations are arbitraged out is taken as an indicator of how well the market works. In this respect, higher elasticity of financing growth to productivity growth would be an apter measure of efficient capital allocation than higher elasticity to value added growth.

Our aim is to compare and assess the different implications of the finance and macro approaches to the measurement of capital allocative efficiency, by focusing on the relation between credit and productivity. Our interest is motivated by the prominent role that productivity has for long-term growth and, ultimately, by the need of better understanding the link between finance and growth also from a macroeconomic point of view. In so doing, we rely on a novel dataset that allows us to tease out the specific relation between bank credit growth and productivity growth at firm level for a rich set of industry in the largest economies of the Eurozone before and after the global financial crisis.

We proceed in two steps. First, we propose a simple theoretical framework that can be used to provide guidance on how to interpret the elasticity of credit growth to productivity growth at the firm level. We consider the case of an entrepreneur who pursues short-term and long-term investment projects with the latter requiring credit. Projects are subject to productivity shocks and the entrepreneur is also subject to liquidity shocks that may kill profitable long-term projects before they can actually deliver any return. Credit constraints limit the amount of bank money the entrepreneur can borrow to face the liquidity shocks so that she has to rely on own money set aside from the cash flow generated by her short-term projects. A key insight of the proposed model is that the sign and the absolute size of the elasticity crucially depends on the extent of credit frictions.

In this setup, due to credit constraints, positive productivity shocks to short-term projects have two effects. On the one hand, they make short-term projects more appealing than long-term ones in terms of intertemporal investment choices, thereby reducing the entrepreneur's demand of credit to finance long-term projects ('opportunity cost effect'). On the other hand, positive productivity shocks to short-term projects increase the short-term cash flow and thus the entrepreneur's ability to keep long-term projects alive in case of liquidity shocks, thereby raising the entrepreneur's credit demand to support those projects ('liquidity effect'). The net effect of short-term productivity growth on bank credit growth is therefore ambiguous, being positive with severe credit constraints and negative with mild ones, as in the former case the liquidity effect dominates, while in the latter it is dominated by the opportunity cost effect. Accordingly, the elasticity of bank credit growth to contemporaneous productivity growth can be positive or negative. If it is positive, the larger its value, the lower the efficiency of bank credit allocation. If negative, the larger its absolute value, the higher the efficiency of bank credit allocation. Differently, positive productivity shocks to long-term projects have only an opportunity cost effect, raising the entrepreneur's demand of credit to support long-term investment: the elasticity of bank credit growth to future productivity growth is positive no matter how severe credit constraints are; the more positive it is, the higher the efficiency of bank credit allocation.

In the second step, we bring the predictions of our theoretical framework to firm-level data on the three biggest Eurozone economies (France, Germany and Italy). This allows us to provide a comprehensive analysis of the relation between bank credit growth and productivity growth since the late 1990s and, through the lenses of the model, to make normative statements about the efficiency of credit allocation across countries, between small and large firms, as well as before and after the global financial crisis. We do so by exploiting the novel firm-level dataset of the Competitiveness Research Network (CompNet) set up by the EU System of Central Banks. A unique feature of this source is that it provides comparable indicators of detailed firm-level characteristics across Eurozone countries. We also leverage the associated research network using data separately managed by the Banque de France for France, the Deutsche Bundesbank for Germany and the national statistical institute ISTAT for Italy.

Based on our proposed measure of credit allocative efficiency, our empirical findings reveal a clear divide between the Eurozone's 'core' (France and Germany) and its 'periphery' (Italy) in terms of the relative strength of the opportunity cost and the liquidity effects. In particular, we find that in France and Germany the elasticity of credit growth to contemporaneous productivity growth is negative whereas it is positive in Italy. In our framework this pattern implies that credit allocation is significantly more efficient in the former countries than in the latter. While this conclusion is hardly surprising, what is instead crucial is the fact that, if we had relied on the traditional measure of allocative efficiency based on the elasticity of investment growth to real value added growth, we would have reached the opposite conclusion: Italy would have been assessed as more efficient than Germany. We also find that, according to our measure, credit tends to be allocated more efficiently across small than across large firms, and some evidence that the efficiency of credit allocation in the Eurozone slightly improves after the global financial crisis.

Our paper not only contributes to the aforementioned literature on the efficiency of capital allocation, but also to the body of studies on finance and economic growth such as King and Levine (1993), Levine (1997), Rajan and Zingales (1998), Guiso et al. (2004), Levine (2005), Ciccone and Papaioannou (2006), and Beck et al. (2008). Finally, it speaks to the works on resource misallocation in Europe, such as Gopinath et al. (2017), Calligaris et al. (2017), and Benigno and Fornaro (2014). These works argue that capital misallocation, especially after the introduction of the Euro, contributed to the productivity slowdown of countries in Southern Europe. Our findings on the allocation of bank credit are consistent with that view.

The rest of the paper is structured as follows. Section 2 introduces the theoretical model to be used as a guide to interpreting and testing the interaction between bank credit and productivity. Section 3 presents the empirical specifications. Section 4 discusses the corresponding empirical results. Section 5 checks their robustness. Section 6 concludes.

2 Credit and Productivity Growth

Consider an entrepreneur who lives for three periods indexed $s \in \{t-1, t, t+1\}$. The entrepreneur maximizes the linear intertemporal utility function

$$U_{t-1} = \sum_{s \in \{t-1,t,t+1\}} \beta^{s-t+1} \Pi_s, \tag{1}$$

where Π_s is consumption ('dividends') in periods s expressed in units of a numeraire final good and $\beta \in (0,1)$ is a discount factor. In each period s the entrepreneur supplies units of the final good, employing own labor L_s and a capital good K_s in a constant-return-to-scale Cobb-Douglas production function

$$Y_s = A_s K_s^{\alpha} L_s^{1-\alpha}, \ \alpha \in (0,1),$$

where A_s is total factor productivity. We assume that productivity follows a deterministic trajectory so that not only A_{t-1} but also A_t and A_{t+1} are known to the entrepreneur in period $t-1$.

While in all periods labor comes as a constant endowment $L_s = 1$, the capital good does not. In particular, despite starting with a fixed endowment $K_{t-1} = K$ of the capital good in the initial period, the entrepreneur has produce the quantities K_t and K_{t+1} to be used in the next periods. She does so by using a fixed amount of human capital H (consisting of skills and know-how) she accumulates in period $t-1$ through her experience in production. The technology needed to transform human capital into capital goods is, however, available only in period t and is linear: $K_t + K_{t+1} = H$.[1] Units of human capital are chosen such that $H = 1$ so that we can interpret K_t and K_{t+1} as the shares of human capital allocated to the supply of capital goods in periods t and $t+1$ respectively. Once produced, K_t is ready for

[1]See Aghion et al (2010) for a similar setup.

use in period t, whereas K_{t+1} needs additional tooling at cost ηK_{t+1}, with $\eta \in (0,1)$, to be paid in period t for use in period $t+1$. This cost is incurred in units of numeraire and has to be paid upfront before final production takes place in period t. It must thus be financed either by using cash D_{t-1} saved from period $t-1$ or by borrowing F_t from the financial markets given that there is no cash flow yet available in period t. Borrowing and lending in any period s face a risk-free interest rate R_s.

The tooling cost is not the only reason for borrowing. At the beginning of period $t+1$, before final production takes place, the entrepreneur is hit by a liquidity shock of size S_{t+1} randomly drawn from a uniform distribution with c.d.f. $\Phi(S_{t+1}) = S_{t+1}/S_{\max}$ for $S_{t+1} \in [0, S_{\max}]$. Accordingly, larger $S_{\max}$ implies positive probability of larger shocks.

If the entrepreneur does not meet the liquidity shock, her activity terminates and production in period $t+1$ does not take place. We assume that there is a secondary market for K_{t+1} so that the entrepreneur is always able to exactly repay F_t with interest upon liquidation of her activity. The liquidity shock can be met by using own cash flow if the entrepreneur has set aside enough from previous periods' sales Y_{t-1} and Y_t, or by raising additional funding B_{t+1} from the financial markets at risk-free interest rate R_t. In order to characterize S_{t+1} as a pure liquidity shock, we assume that, if the entrepreneur meets S_{t+1} at the beginning of period t, at the end of period $t+1$ she will receive an equal payment. This allows us to focus on investment trajectories that would be always worthwhile pursuing by the entrepreneur in the absence of the liquidity shock. Indeed, with such payment it will always be in the entrepreneur's interest to meet the liquidity shock as long as she has enough resources given that at the beginning of period $t+1$ the net value of meeting the liquidity shock is $Y_{t+1} > 0$.[2]

We consider two cases for the working of financial markets. When financial markets are *complete*, positive continuation value implies that the entrepreneur can always raise as much external funding as she needs to meet the liquidity shock. The liquidity shock is therefore immaterial for the entrepreneur's allocation of human capital between K_t and K_{t+1}. In this case, the entrepreneur faces the following budget constraints. In period $t-1$, dividends

[2]See Aghion et al (2010) for a similar assumption.

Π_{t-1} and savings D_{t-1} equal cash flow Y_{t-1}:

$$\Pi_{t-1} + D_{t-1} = Y_{t-1}. \tag{2}$$

In period t, dividends Π_t and the tooling cost ηK_{t+1} have to be matched by own cash flow Y_t, lending repayment with interest $(1 + R_{t-1})D_{t-1}$ or external finance F_t raised to cover the tooling cost:

$$\Pi_t + \eta K_{t+1} = Y_t + (1 + R_{t-1})D_{t-1} + F_t. \tag{3}$$

In period $t + 1$, dividends Π_{t+1}, loan repayments with interest $(1 + R_t)\, F_t$ and borrowing B_{t+1} to cover the liquidity shock have to be matched by cash flow from production Y_{t+1} and reinstated liquidity S_{t+1}:

$$\Pi_{t+1} + (1 + R_t)F_t + B_{t+1} = Y_{t+1} + S_{t+1}. \tag{4}$$

Due to linear utility $1 + R_s = \beta^{-1}$ holds in all periods.

When capital markets are *incomplete*, the entrepreneur faces a borrowing constraint at the beginning of period $t + 1$ that prevents her from raising any additional funding ($B_{t+1} = 0$). The underlying assumption is that, with incomplete markets, the entrepreneur needs collateral for borrowing. In particular, she must pledge K_{t+1} as collateral to secure a loan $F_t > 0$ for the tooling cost and has no collateral left to secure a loan $B_{t+1} > 0$ for the liquidity shock. Hence, she can meet the liquidity shock only with own cash flow Y_t and lending repayment $(1 + R_{t-1})D_{t-1}$.

The entrepreneur's program is then to maximize her payoff (1) with respect to Π_{t-1}, Π_t and Π_{t+1}, subject to the budget constraints (2), (3) and (4), taking into account the technological possibilities for intermediate production ($K_t + K_{t+1} = 1$) and final production ($Y_{t-1} = A_{t-1}K^\alpha$, $Y_t = A_t K_t^\alpha$ and $Y_{t+1} = A_{t+1}K_{t+1}^\alpha$), as well as the lending and borrowing possibilities (D_{t-1}, F_t and B_{t+1}) at common interest rate $(\beta^{-1} - 1)$. When financial markets are incomplete, the entrepreneur also faces an additional borrowing constraint and accordingly does not receive any related payment: $B_{t+1} = S_{t+1} = 0$ in (4). By substituting the various constraints into (1), the entrepreneur's maximization of U_{t-1} boils down to maximizing

$$A_{t-1}K^{\alpha} + \beta\left(A_t K_t^{\alpha} - \eta K_{t+1}\right) + \beta^2 S_{\max}^{-\phi}\left(A_t K_t^{\alpha} + \beta^{-1}A_{t-1}K^{\alpha}\right)^{\phi} A_{t+1}K_{t+1}^{\alpha} \quad (5)$$

with respect to K_t and K_{t+1} subject to $K_t + K_{t+1} = 1$. The parameter ϕ is introduced in order to have a single expression encompassing complete and incomplete markets for $\phi = 0$ and $\phi = 1$ respectively. In (5) $A_t K_t^{\alpha} + \beta^{-1}A_{t-1}K^{\alpha} = Y_t + \beta^{-1}Y_{t-1}$ is the largest cash flow the entrepreneur can generate before the liquidity shock hits. This determines the largest shock she can afford to meet with own cash. Hence, when financial markets are incomplete, $S_{\max}^{-\phi}\left(A_t K_t^{\alpha} + \beta^{-1}A_{t-1}K^{\alpha}\right)^{\phi}$ with $\phi = 1$ is her probability of surviving the liquidity shock. Differently, when financial markets are complete, the probability of surviving the liquidity shock equals one no matter how large the shock is, as implied by $S_{\max}^{-\phi}\left(A_t K_t^{\alpha} + \beta^{-1}A_{t-1}K^{\alpha}\right)^{\phi} = 1$ for $\phi = 0$.

The amount of credit the entrepreneur raises in period t is $F_t = \eta K_{t+1} - \beta^{-1}A_{t-1}K^{\alpha}$, which is the difference between the tooling cost of K_{t+1} and cash brought forth with interest from period $t-1$ to period t. We are interested in situations in which $F_t > 0$ so that the entrepreneur does need credit to cover the tooling cost. Given $K_{t+1} \in [0, 1]$, a sufficient condition for that to happen is $\eta > \beta^{-1}A_{t-1}K^{\alpha}$, which we assume to hold henceforth. In order to characterize the response of credit growth to productivity growth, we consider a baseline scenario in which productivity is the same in all periods ($A_{t-1} = A_t = A_{t+1} = A$). We then compare the baseline with two alternative scenarios: one in which there is productivity growth from period $t-1$ to period t (i.e. $A_t > A_{t-1} = A_{t+1} = A$) and another in which there is productivity growth from period t to period $t+1$ (i.e. $A_{t+1} > A_{t-1} = A_t = A$). As the entrepreneur does not borrow in period $t-1$, we can use the first alternative scenario to assess the reaction of credit growth in period t to *contemporaneous* productivity growth, and the second to assess its reaction to *future* productivity growth.

A crucial implication of the first order condition for the entrepreneur's maximization program is that with complete markets a positive shock to A_t raises the marginal product of K_t without affecting the marginal product of K_{t+1}.[3] Hence, larger A_t reduces borrowing for the tooling cost $F_t = \eta K_{t+1} - \beta^{-1}A_{t-1}K^{\alpha}$. Differently, with incomplete markets larger A_t,

[3]The first order conditions are derived, reported and discussed in the Appendix A.1.

by increasing the cash flow $Y_t + \beta^{-1} Y_{t-1} = A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha}$, also raises the probability of surviving the liquidity shock. It thus increases the *expected* marginal product of K_{t+1} and borrowing for the tooling cost. In the former case, a standard 'opportunity cost effect' is at work that increases the incentive to use human capital to produce K_t. In the latter case, the opportunity cost effect is still at work but faces an opposite 'liquidity effect': larger A_t increases the cash flow in period t and, through this channel, the entrepreneur's ability to meet the liquidity shock. This reinforces her incentive to use human capital to produce K_{t+1}. Hence, whereas with complete capital markets larger A_t makes the entrepreneur raise her supply of K_t to the detriment of K_{t+1}, with incomplete capital markets it may lead to the opposite outcome whenever the increase in the probability of surviving thanks to more liquidity available is large enough to make the liquidity effect dominate the opportunity cost effect. Given $\Phi(S_{t+1}) = S_{t+1}/S_{\max}$, this happens when $S_{\max}$ is small enough, that is, when the largest size of possible liquidity shocks is small enough.[4]

All this implies that, as long as the entrepreneur needs borrowing to cover the tooling cost, a positive shock to A_t always *decreases* contemporaneous credit F_t with complete markets, but can *increase* it with incomplete markets. This ambiguity does not arise, instead, for a positive shock to A_{t+1} as higher productivity in period $t+1$ has no bearing on cash flow in period t and thus does not have any liquidity effect.[5]

These insights can be summarized in the following proposition:

Proposition 1 *(a) With complete financial markets, the elasticity of credit growth to* contemporaneous *productivity growth is always negative due to an opportunity cost effect. (b) With incomplete financial markets, it can be positive as there is also an opposing liquity effect. (c) The elasticity of credit growth to* future *productivity growth is always positive no matter whether financial markets are complete or incomplete as only the opportunity cost effect is at work.*

Proof. See Appendix A.2. ■

[4] See Appendix A.2 for analytical details.

[5] Further comparison between complete and incomplete markets sheds additional light on how the liquidity effect works. With complete markets the entrepreneur is able to achieve her unconstrained optimal amount of long-term capital K_{t+1}^*. Differently, with incomplete markets the chosen (cash-flow) constrained optimal amount K_{t+1} is below the optimal target: $K_{t+1} < K_{t+1}^*$. In this case, though larger A_t makes the unconstrained K_{t+1}^* fall due to the opportunity cost effect, the constrained K_{t+1} can actually rise as long as, by increasing available cash flow, larger A_t increases K_{t+1} towards the falling but still larger target K_{t+1}^*.

From an empirical point of view, this proposition implies that the sign and (absolute) size of the estimated elasticity of credit growth to contemporaneous productivity growth can be used to assess and compare the efficiency of financial markets by exploiting cross-country firm panel data. Countries featuring positive elasticity suffer from severe financial market frictions and credit misallocation, the more so the larger the elasticity's value. Vice versa, in countries exhibiting negative elasticity, financial market frictions and credit misallocation are limited, the more so the larger the elasticity's absolute value. In the next section we will use these insights to assess and compare the efficiency of credit allocation across firms in the three largest Eurozone economies.

3 Data Description

We use a novel firm-level dataset based on the CompNet database (www.comp-net.org) kick-started by the European Central Bank (ECB). A unique feature of this source is that it provides comparable indicators of detailed firm-level characteristics across a large set of European Union (EU) countries. Firm-level data are extremely sensitive and are handled by different national institutions under severe confidentiality requirements that typically make the creation of pooled cross-country firm-level datasets very hard. CompNet has managed to reduce the shortcomings of this situation for research by agreeing with the different national institutions a common protocol on how harmonized indicators should be defined and produced for detailed categories of firms. It has also created a network of researchers in the different national institutions that cooperate in the production of additional specific ouputs that are not included in the shared database.

Our analysis leverages both the CompNet database and the associated research network using data separately managed by the Banque de France for France, the Deutsche Bundesbank for Germany and the national statistical institute ISTAT for Italy. These institutions combine multiple sources of national administrative data (such as financial statements, fiscal forms, firm surveys, employment registries) to offer complete and detailed overviews of firm characteristics in the corresponding countries.

Table 1 shows the number of years, the number of firms and the original source of data by country. Even though variables are harmonised across countries, there are still some differences in terms of years of coverage and number of firms available. Nonetheless, this incomplete overlap pales in front of the representativeness of the sample and the richness of available variables, which are unique cross-country characteristics of the CompNet database.[6] In particular, for France, Germany and Italy Table 1 reveals that the firms in the sample cover between 27% and 43% of value added in national accounts and between 20% to 36% of total employment. Table 2 reports, instead, the employment distributions by firm size class in CompNet and Eurostat, highlighting remarkable sample representativeness for all three countries as the two distributions are very similar.

For each firm in the sample we have information on various measures of 'productivity', such as total factor productivity (TFP), marginal product of capital and labor productivity, as well as data on real value added. Firm-level TFP is computed using the approach of Wooldridge (2009), which hinges on previous work by Olley and Pakes (1996) and Levinshon and Petrin (2003).[7] The marginal product of capital is defined as the ratio of real value added over capital stock accounting for the firm-level elasticity of capital in the production function. Labor productivity is defined as real value added per employee. Finally, real value added is computed using country-sector specific deflators.

For each firm we also have information on bank credit, leverage and return on assets. Bank credit corresponds to the entry 'liabilities to financial institutions'. in firm's balance sheets.[8] Returns on assets are defined as operating profit/loss over total assets. Leverage is the ratio of total debt to total assets.

4 Econometric Specification

The traditional empirical approach to assess the efficiency of credit allocation is to regress the growth rate of investments (a proxy for credit) on the growth rate of real value added (a proxy for investment opportunities) at the industry level (Wurgler, 2000). The size of the

[6] A detailed overview of the CompNet database can be found in Lopez-Garcia and di Mauro (2015).

[7] See Appendix A.3 for additional details on how TFP is estimated from firms' balance sheets.

[8] We do not have data on issued shares and data on bonds are scarce. This should not introduce any relevant bias in our results as the number of firms that issue bonds in our sample is very limited.

resulting estimated elasticity of investment to real value added measures how fast credit is directed to its most promising uses and thus how efficiently credit is allocated at any point in time.

Our empirical approach is close to the traditional approach, but it aims to bring it forward in three main respects. First, we are able to look at credit directly without having to use investment as a proxy. Second, we can run the analysis at the firm level rather than at the industry level, thus capturing the within-sector dimension of allocative efficiency. Third, we bring productivity growth into the main picture as an aspect of investment opportunities that may be important for the assessment of efficient capital allocation across firms.

Following the implications of the model proposed in Section 2, our main specification investigates the relations of credit growth with current and future productivity growth separately. For comparison with the traditional approach, we also run the same specification using current and future real value added growth. The specification is run independently for each country (given that, as discussed in Section 3, data cannot be pooled) with yearly time frequency. Specifically, omitting the country index for parsimonious notation, we run the following regressions for firm i in year t:

$$\begin{aligned} Credit\ growth_{it} &= \beta_0 + \beta_1 Productivity\ growth_{it} \\ &\quad + \beta_2 Growth\ with\ internal\ funds_{it} \\ &\quad + \beta_3 Leverage_{it-1} + \delta_t + \psi_i + \epsilon_{it} \end{aligned} \tag{6}$$

and

$$\begin{aligned} Credit\ growth_{it} &= \alpha_0 + \alpha_1 Productivity\ growth_{it+1} \\ &\quad + \alpha_2 Growth\ with\ internal\ funds_{it} \\ &\quad + \alpha_3 Leverage_{it-1} + \delta_t + \psi_i + \epsilon_{it}. \end{aligned} \tag{7}$$

Analogous regeressions are also run replacing productivity growth with real value added growth. In (6) and (7) the main coefficients of interest are β_1 and α_1 as these capture the relation of credit growth with current and future productivity growth respectively. The regressions are saturated with a series of controls and fixed effects to account for possibly relevant aspects our simple model abstracts from. In particular, 'Leverage_{t-1}' is introduced as a proxy of firm financial health and controls for its risk profile. The variable $Growth\ with\ internal\ funds_{it}$ is a proxy to control for credit demand across firms. It refers to the maximum level of growth that a firm can attain without external finance. The measure capture a firm-level measure of external financial independence and it is computed following the 'percentage of sales' approach to financial planning as in Higgins (1977) and Guiso et al. (2004).[9] The time dummy δ_t captures shocks common to all firms while the firm fixed effect ψ_i absorbs the firm's time invariant characteristics that may affect credit provision but are not in the model (such as skills and human capital) as well as the intrinsic external financial needs of the specific sector the firm operates in.[10] In the baseline specification, productivity is measured as TFP while we use the marginal product of capital and labor productivity to check robustness.

Four remarks on specification (6) and (7) are in order. First, when looking at β_1 and α_1 through the lenses of Proposition 1, we expect α_1 to be positive while the sign and absolute size of β_1 is informative about constraints that hamper an efficient credit allocation: negative β_1 signals efficiency, the more so the larger it is; positive β_1 signals inefficiency, the more so the larger it is in absolute value.

Second, β_1 and α_1 are coefficients that capture the equilibrium relation between productivity and credit growth. We do not give a causal interpretation to the coefficients given that credit may lead to a contemporaneous change in productivity and also affect future productivity.[11] However, we can read the coefficients through the lenses of our model, which provides guidance about how to interpret the equilibrium outcome between productivity and credit.

Third, the empirical analysis is based on a cross-country comparison. As Table 2 shows, Italian firms tend to be significantly smaller than French and German firms. This implies

[9] Specifically, we define: $Growth\ with\ internal\ funds_{it} = ROA/(1 - ROA)$. In Higgins (1977) this is called 'maximum rate of internally financed growth' and is used to derive '$\text{FinancialDemand}_{it}$'$= 1 - ROA/(1 - ROA)$.

[10] We also added sector-time dummies but results barely change.

[11] Reverse causality is less of a concern for β_1, as in Appendix A.3 we show that the measure of capital that we use to compute TFP is a function of past investments, which implies that the estimated productivity at time t does not depend on capital, and thus on credit, at time t. Whereas, the extent of the impact of reverse causality for estimating α_1 in equation (7) depend on the time needed for capital installation to affect total factor productivity, which in some cases could exceed one year and hence not affect our estimates.

that our results could be driven either by the inherent allocative efficiency of credit or by the distribution of firm size across countries. Therefore, we run the specifications (6) and (7) by splitting our sample between firms below and above 50 employees, and the results do not change.

Fourth, in regression (7) as in the model we do not draw a distinction between unobserved future expected productivity growth and its observed realizationl. The two measures would be equivalent only if banks had perfect foresight. As this is unlikely to hold in reality, it introduces some measurement error in the independent variable of interest and generates an attenuation bias in the estimates. In this respect, our results can be seen as providing a lower bound for the elasticity of credit to expected productivity as well as for the elasticity differences across countries.

5 Empirical Results

Table 3 presents our main results. The first row shows the elasticity of credit to TFP and real value added by country at t and $t+1$.[12] For France and Germany the table reveals a significant negative elasticity of credit to current productivity ($\beta_1 < 0$) and a significant positive elasticity of credit to future productivity ($\alpha_1 > 0$). For Italy, the elasticity of credit to future productivity is again significantly positive though smaller in size ($\alpha_1 > 0$). However, that turns out to hold also for the elasticity of credit to current productivity ($\beta_1 > 0$). According to Proposition 1, this is evidence that the opportunity cost effect of current productivity growth dominates in France and Germany while its liquidity effect dominates in Italy. For this reason credit allocation appears to more efficient in the former countries than in the latter. Moreover, as the size of the coefficients is larger for France than for Germany, credit allocation appears to be more efficient in France than in Germany.

Interestingly, the second row of Table 3 shows also that, if we had relied on the traditional assessment of efficient credit allocation based on the relation between credit growth and current real value added growth, we would have reached quite different and possibly

[12] For ease of exposition, we present only the main coefficients of the regressions. The full tables of these regressions are reported in Appendix A.3.

misleading conclusions. In particular, Germany exhibits an elasticity of credit to current real value added not significantly different from zero, compared to significantly positive elasticities of 17% and 11% for France and Italy respectively. Therefore, following the traditional approach we would have concluded that credit is allocated more efficiently in Italy than in Germany. This does not seem to be plausible as one would need to explain why firms in Germany are more credit constrained than firms in Italy.

Table 4 extends the analysis by looking at differences between large and small firms.[13] The table shows that the baseline results are qualitatively confirmed across firm size classes for both measures and all three countries. The only exception concerns large firms in Italy, for which the elasticities of bank credit to current and future productivity are not significantly different from zero. While the lack of significant correlation between credit growth and current productivity growth could be interpreted through the model in terms of offsetting opportunity cost and liquidity effects, the insignificant relation of credit growth with future productivity growth is hard to explain unless Italian firms and banks do not have productivity growth in their radar when demanding and supplying external finance. Turning to France and Germany, Table 4 reveals significant differences in the magnitude of the coeffcients between small and large firms. The elasticity of credit to productivity is inversely correlated with firm size, which suggests that bank credit is allocated more efficiently across small than large firms. A possible explanation for this finding is that relational banking may matter more for large firms. Given that large firms are cross-selling clients for which credit represents only one of many financial services they may ask from banks, these could choose to finance also less promising projects by such firms provided that the overall business relation remains profitable. Nonetheless, while this strategy can be individually optimal from a bank's perspective, it still has macroeconomic implication in terms of credit misallocation from an aggregate productivity perspective. A second possible explanation is that large firms are less dependent from bank credit than small firms thanks to better access to capital markets. A third explanation could be that the average commitment and complexity of credit to larger firms is higher so that it might be more complicated to reallocate credit between large than small firms.

[13]The threshold between small and large firms that we apply is 50 employees.

6 Robustness Checks

In this section we focus on two main issues. First, we analyse the robustness of our findings to alternative measures of firm productivity. Second, we check whether the global financial crisis plays any role in shaping those findings.

It might be argued that the marginal revenue product of capital (MRPK) rather than TFP is the relevant measure of productivity from the point of view of banks. Moreover, TFP as well as the marginal product of capital could be more difficult to compute for credit institutions than labor productivity. Table 5 reports the estimates of β_1 and α_1 from regressions (6) and (7) when TFP is replaced by MRPK and labor productivity ('LProd') as measures of firm productivity. We find that for France and Germany the results are virtually unchanged. Credit at time t exhibits significant negative elasticity ($\beta_1 < 0$) with respect to both measures at time t and significant positive elasticity ($\alpha_1 > 0$) at time $t+1$. In the case of Italy the same holds for labor productivity both at t and $t+1$, but only at $t+1$ for MRPK as the elasticity of credit to MRPK is significantly negative. That said, the absolute sizes of the Italian elasticities of credit to MRPK are both an order of magnitude smaller than the French and German ones, confirming that credit is less efficiently allocated in Italy than in France and Germany. Moreover, they are so small that, even though statistically different from zero, they are hardly different from zero from an economic point of view.

Turning to the global financial crisis, Table 6 splits the sample between pre-2008 and post-2009 periods. From a qualitative viewpoint, the results for all three countries do not change before and after the crisis. They change, however, from a quantitative viewpoint. For Germany there is some evidence of credit allocation becoming slightly more effcient after the crisis, as the elasticities of credit to TFP at time t and $t+1$ become larger in size. The opposite is observed for France, although the sizes of the French elasticities remain significantly larger than the German one. Differently, for Italy there is virtually no change between the two periods. These results suggest that the baseline findings are not driven by the global financial crisis.

7 Conclusions

This paper contributes to the literature on the measurement of efficient capital allocation by credit markets. Focusing on bank credit growth and firm productivity growth, it has extended the traditional approach that assesses allocative efficiency through the elasticity of investment growth to real value added growth growth. In particular, we have proposed a new methodology based on a simple model of investment linking the signs and absolute sizes of the elasticities of credit growth to current and future productivity growth to the harshness of credit constraints.

The model highlights that, whereas the effect of future productivity growth on current credit growth is always positive, the contemporaneous net effect of productivity growth on credit growth is ambiguous: positive with severe credit constraints and negative with mild ones as a liquidity effect dominates in the former case and an opportunity cost effect dominates in the latter. In light of the model, a positive elasticity of credit growth to contemporaneous productivity growth signals lower efficiency, the more so the larger its absolute value; a negative elasticity signals instead higher efficiency, the more so the larger its absolute value.

We have used this conceptual framework to assess the efficiency of credit allocation in the three largest Eurozone economies (France, Germany and Italy), exploiting a unique micro dataset based on the CompNet database created by the ECB. This dataset has allowed us to estimate the elasticity of credit growth to current and future productivity growth and real value added growth at the firm level. For France and Germany we have found significantly negative elasticity of credit growth to current productivity growth and significantly positive elasticity of credit growth to future productivity growth. Also for Italy the elasticity of credit growth to future productivity growth, though smaller, has been found again significantly positive. However, the elasticity of credit growth to current productivity growth has turned out to be also significantly positive. Reading these results through the lenses of our model suggests that credit allocation is more effiecient in France and Germany than in Italy. While this finding is hardly surprising, it should be seen as a promising feature of our new methodology, given that we have also shown that the traditional approach based on real value added rather than productivity delivers the opposite and arguably implausible conclusion that credit is more efficiently allocated in Italy than in Germany.

When comparing different firm size classes, we have found that the elasticity of credit growth to productivity growth is generally higher for small than large firms, suggesting that credit is allocated more efficiently among the former than the latter. This is an important finding as large firms represent a dominant share of employment and value added in our sample economies.

Finally, we have shown that our results are robust to alternative measures of productivity, and hold qualitatively both before and after the global financial crisis. The estimated elasticities of credit growth to productivity growth are nonetheless quantitatively different in the pre- and post-crisis periods. In Germany credit allocation appears to become more efficient after the crisis while the opposite pattern is observed in France. Differently, in Italy there is virtually no change between the two periods.

References

[1] Aghion, P., Angeletos,, G.-M., Banerjee, A., Manova, K. 2010. "Volatility and growth: Credit constraints and the composition of investment," Journal of Monetary Economics, 57, 246-265.

[2] Beck, T., Demiguruc-Kint, A., Laeven, L., Levine, R., 2008. "Finance, firm size, and growth," Journal of Money, Credit, and Banking, 40, 1379-1405.

[3] Beck, T., Demiguruc-Kint, A., Levine, R., 2007. "Finance, firm size, and growth," Journal of Economic Growth, 12(1), 27-49.

[4] Calligaris, S., Del Gatto, M., Hassan, F., Ottaviano, G.I.P., and F. Schivardi. 2016. "Italy's Productivity Conundrum: a Study on Resource Misallocation in Italy", European Commission Discussion Paper, n. 030, May 2016.

[5] Caselli, F. 2005. "Accounting for Cross-Country Income Differences", in Handbook of Economic Growth, ed. by P. Aghion, and S. Durlauf, 1, 679-741.

[6] Ciccone, A., Papaioannou E., 2006. "Adjustment to target capital, finance, and growth," CEPR Discussion Paper n. 5969.

[7] Gopinath, G., Kalemli-Ozcan S., L. Karabarbounis L., and C. Villegas-Sanchez, 2015. "Capital Allocation and Productivity in South Europe," NBER Working Paper No. 21453.

[8] Guiso, L., Sapienza P., Zingales, L., 2004. "Does local nancial development matter?," Quarterly Journal of Economics, 119, 929-969.

[9] Hartmann, P., Heider, F., Papaioannou, E., Lo Duca, M., 2007. "The Role of Financial Markets and Innovation in Productivity and Growth in Europe," ECB Occasional Paper n. 72.

[10] Hsieh, C.-T., Klenow, P., 2009. "Misallocation and manufacturing TFP in China and India." Quarterly Journal of Economics, 74, 1403-1448.

[11] Higgins, R.C., 1977. "How much finance can a firm afford?," Financial Management, 6, 3-16.

[12] Hubbard, R., 1998. "Capital-market imperfections and investment," Journal of Economic Literature, 36,193–225.

[13] Jensen, M., 1986. "Agency costs of free cash flow, corporate finance and takeovers," American Economic Review, 76, 323-329.

[14] King, R.G., Levine, R., 1993. "Finance and growth: Schumpeter might be right," Quarterly Journal of Economics, 108, 717-738.

[15] Lee, D., Shin, H., Stultz, E.M., 2016. "Why Does Capital No Longer Flow More to the Industries with the Best Growth Opportunities?," NBER Working Paper No. 22924.

[16] Levine, R., 1997. "Financial development and economic growth: views and agenda," Journal of Economic Literature, 35, 688-726.

[17] Levine, R., 2005. "Finance and growth: theory and evidence," in Handbook of Economic Growth, P. Aghion and S.N. Durlauf (eds.), Elsevier B.V.

[18] Levinsohn, J., Petrin, A., 2003. "Estimating Production Functions Using Inputs to Control for Unobservables," Review of Economic Studies, 70, 317-342.

[19] Morck, R. Deniz Yavuz, M., Yeung, B., 2011. "Banking system control, capital allocation, and economy performance," Journal of Financial Economics, 100, 264-283.

[20] Olley, G.S., Pakes, A., 1996. "The dynamics of productivity in the telecommunications equipment industry," Econometrica, 64, 1263-1297.

[21] Rajan, R.G., Zingales, L., 1998. "Financial dependance and growth," American Economic Review, 88, 559-586.

[22] Wooldridge, J.M., 2009. "On estimating rm-level production functions using proxy variables to control for unobservables," Economics Letters, 104,112-114.

[23] Wurgler, J., 2000. "Financial markets and the allocation of capital," Journal of Financial Economics, 58, 187-214.

8 Figures

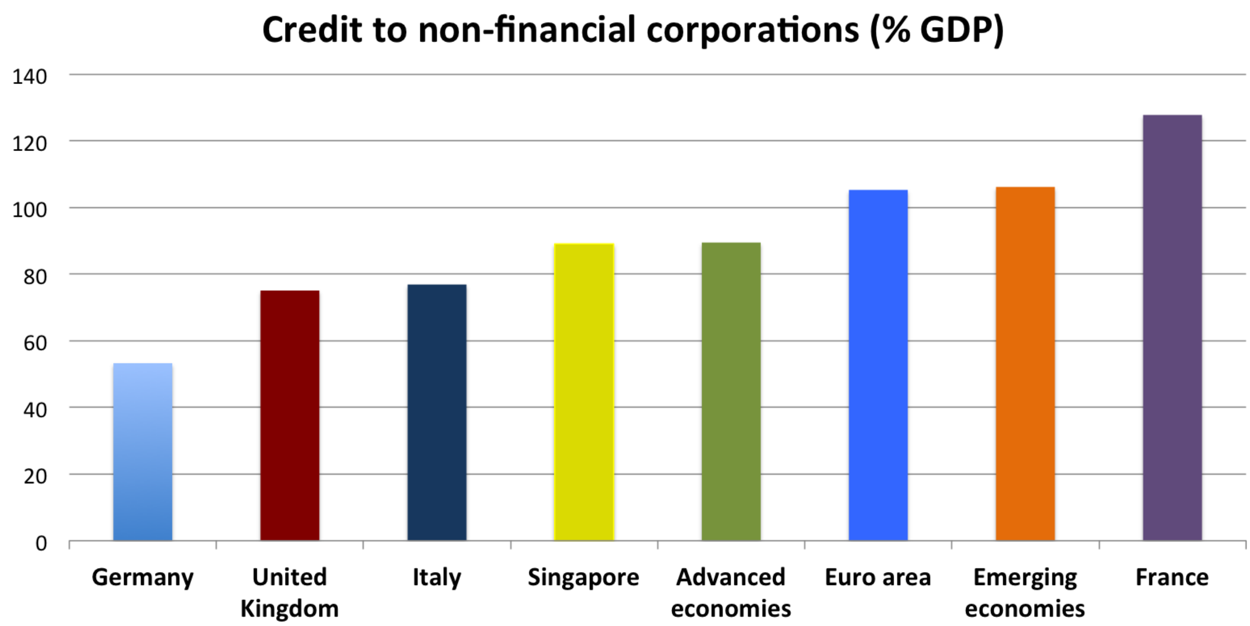

Figure 1: Credit to non-financial corporations

Tables

Table 1: Sample summary

Country	**France**	**Germany**	**Italy**
Data Source	Banque de France	Bundesbank	ISTAT
Years	1995-2012	1997-2012	2001-2012
Firms	93,569	42,726	393,489
Observations	589,609	184,807	1,721,881
Value added vs Eurostat	43%	32%	27%
Total employment vs. Eurostat	36%	20%	30%

Table 2: Employment distribution by firm size class, CompNet and Eurostat

Size class	**20-49**		**50-249**		**250 +**	
	Eurostat	CompNet	Eurostat	CompNet	Eurostat	CompNet
France	18%	17.7%	24.6%	25%	57.4%	57.3%
Germany	14.9%	14%	29.1%	29.5%	56%	56.5%
Italy	24.1%	24.3%	29.4%	28.9%	46.5%	46.8%

Table 3: Baseline results on loans

Elasticity of credit to:	**France**		**Germany**		**Italy**	
	t	t+1	t	t+1	t	t+1
TFP	-0.27***	0.15***	-0.08***	0.06***	0.02***	0.02***
	(0.01)	(0.01)	(0.007)	(0.008)	(0.001)	(0.001)
RVA	0.17***	0.23***	-0.001	0.09***	0.11***	0.001
	(0.008)	(0.01)	(0.006)	(0.007)	(0.003)	(0.005)

***, **, * Significant at the 1%, 5% and 10% level. *TFP* is total factor productivity and *RVA* is real value added, as defined in Section 3. The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7). All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.

Table 4: Results by firm size

Elasticity of credit to		**France**		**Germany**		**Italy**	
		t	t+1	t	t+1	t	t+1
TFP	Small	-0.29***	0.18***	-0.09***	0.08***	0.02***	0.03***
		(0.01)	(0.01)	(0.02)	(0.01)	(0.001)	(0.001)
	Large	-0.22***	0.09***	-0.08***	0.05***	-0.002	0.00
		(0.02)	(0.02)	(0.01)	(0.008)	(0.009)	(0.008)
RVA	Small	0.15***	0.20***	-0.003	0.10***	0.12***	0.01
		(0.01)	(0.01)	(0.01)	(0.02)	(0.002)	(0.007)
	Large	0.22***	0.12***	0.00	0.08***	0.05***	0.003
		(0.01)	(0.02)	(0.009)	(0.008)	(0.01)	(0.002)

***, **, * Significant at the 1%, 5% and 10% level. *TFP* is total factor productivity and *RVA* is real value added, as defined in Section 3. The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7) for each sub-sample of firm size. All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.

Table 5: Robustness to alternative productivity measures

Elasticity of credit to:	**France**		**Germany**		**Italy**	
	t	t+1	t	t+1	t	t+1
MRPK	-0.51***	0.08***	-0.24***	0.05***	-0.003***	0.002***
	(0.007)	(0.007)	(0.006)	(0.005)	(0.000)	(0.000)
LProd	-0.17***	0.10***	-0.07***	0.06***	0.05***	0.04***
	(0.008)	(0.01)	(0.006)	(0.007)	(0.001)	(0.001)

***, **, * Significant at the 1%, 5% and 10% level. *MRPK* is the marginal product of capital and *LProd* is labor productivity as defined in Section 3. The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7). All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.

Table 6: Results pre- and post-crisis

Elasticity of credit to		**France**		**Germany**		**Italy**	
		t	t+1	t	t+1	t	t+1
TFP	Pre-crisis	-0.32***	0.16***	-0.07***	0.06***	0.01***	0.02***
		(0.01)	(0.01)	(0.01)	(0.01)	(0.002)	(0.001)
	Post-crisis	-0.23***	0.12***	-0.11***	0.09***	0.02***	0.03***
		(0.02)	(0.02)	(0.02)	(0.01)	(0.001)	(0.001)
RVA	Pre-crisis	0.14***	0.26***	0.003	0.09***	0.10***	0.02
		(0.01)	(0.01)	(0.01)	(0.02)	(0.006)	(0.02)
	Post-crisis	0.14***	0.11***	-0.01	0.06***	0.12***	0.01
		(0.01)	(0.02)	(0.02)	(0.01)	(0.003)	(0.02)

***, **, * Significant at the 1%, 5% and 10% level. *TFP* is total factor productivity and *RVA* is real value added, as defined in Section 3. The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7) for each sub-sample of firm size. All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level

Appendix A.1: The Entrepreneur's Maximization

The entrepreneur solves the following Lagrangean problem:

$$\begin{gathered}\max_{K_t, K_{t+1}} {}_t = A_t K_t^{\alpha} - \eta K_{t+1} \\ +\beta \left[\left(A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} \right) / S_{\max} \right]^{\phi} A_{t+1} K_{t+1}^{\alpha} + \lambda_t \left(1 - K_t - K_{t+1} \right),\end{gathered}$$

where λ_t is the Lagrangean multiplier on the human capital constraint. The first order conditions with respect to K_t and K_{t+1} are

$$\begin{gathered}A_t \alpha K_t^{\alpha-1} + \beta \left[\phi \left(A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} \right)^{\phi-1} A_t \alpha K_t^{\alpha-1} \left(S_{\max} \right)^{-\phi} \right] \\ \times A_{t+1} K_{t+1}^{\alpha} = \lambda_t\end{gathered} \tag{8}$$

and

$$-\eta + \beta \left(A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} \right)^{\phi} \left(S_{\max} \right)^{-\phi} A_{t+1} \alpha K_{t+1}^{\alpha-1} = \lambda_t \tag{9}$$

respectively, which together imply

$$\begin{gathered}A_t \alpha K_t^{\alpha-1} + \eta = \beta \alpha A_{t+1} K_{t+1}^{\alpha-1} \\ \times \left[\left(S_{\max} \right)^{-\phi} \left(A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} \right)^{\phi} \left(1 - \phi \frac{A_t K_t^{\alpha-1} K_{t+1}}{A_t K_t^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha}} \right) \right].\end{gathered} \tag{10}$$

The first order condition with respect to λ_t recovers the resource constraint

$$1 - K_t - K_{t+1} = 0,$$

which allows us to rewrite (10) as an implicit function of K_{t+1} only:

$$\begin{gathered}A_t \alpha \left(1 - K_{t+1} \right)^{\alpha-1} + \eta = \beta \alpha A_{t+1} K_{t+1}^{\alpha-1} \\ \times \left[\left(S_{\max} \right)^{-\phi} \left(A_t \left(1 - K_{t+1} \right)^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} \right)^{\phi} \right. \\ \left. \times \left(1 - \phi \frac{A_t (1 - K_{t+1})^{\alpha-1} K_{t+1}}{A_t (1 - K_{t+1})^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha}} \right) \right].\end{gathered} \tag{11}$$

The entrepreneur's optimal choice is the solution of (11).

Appendix A.2: Proof of Proposition 1

Given that $F_t = \eta K_{t+1} - \beta^{-1} A_{t-1} K^{\alpha}$ implies $dF_t/dA_t = \eta dK_{t+1}/dA_t$ and $dF_t/dA_{t+1} = \eta dK_{t+1}/dA_{t+1}$, the three statements in the proposition can be proved as follows.

(a) With complete financial markets, the elasticity of credit growth to *contemporaneous* productivity growth is always negative due to an opportunity cost effect. For $\phi = 0$ condition (11) can be written as

$$G(A_t, A_{t+1}, K_{t+1}) \equiv A_t \alpha \left(1 - K_{t+1}\right)^{\alpha-1} + \eta - \beta \alpha A_{t+1} K_{t+1}^{\alpha-1} = 0. \tag{12}$$

The derivative of the implicit function then implies

$$\frac{dK_{t+1}}{dA_t} = -\frac{\frac{dG(A_t, A_{t+1}, K_{t+1})}{dA_t}}{\frac{dG(A_t, A_{t+1}, K_{t+1})}{dK_{t+1}}} = -\frac{\left(1 - K_{t+1}\right)^{\alpha-1}}{(1-\alpha)\left[A_t \left(1 - K_{t+1}\right)^{\alpha-2} + \beta A_{t+1} K_{t+1}^{\alpha-2}\right]} < 0$$

and thus $dF_t/dA_t = \eta dK_{t+1}/dA_t < 0$.

(b) With incomplete financial markets, the elasticity of credit growth to *contemporaneous* productivity growth can be positive as there is also an opposing liquity effect. For $\phi = 1$ condition (8) becomes

$$\begin{aligned} G(A_t, A_{t+1}, K_{t+1}) \equiv{}& A_t \alpha \left(1 - K_{t+1}\right)^{\alpha-1} + \eta - \beta \alpha A_{t+1} K_{t+1}^{\alpha-1} \left(S_{\max}\right)^{-1} \\ & \times \left[A_t \left(1 - K_{t+1}\right)^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} - A_t \left(1 - K_{t+1}\right)^{\alpha-1} K_{t+1}\right] = 0, \end{aligned} \tag{13}$$

where the term between square brackets in positive as its ratio to $S_{\max}$ is the probability of surving the liquidity shock. Given that

$$\begin{aligned} \frac{dG(A_t, A_{t+1}, K_{t+1})}{dK_{t+1}} ={}& A_t \alpha \left(1-\alpha\right)\left(1 - K_{t+1}\right)^{\alpha-2} \\ & + \beta \alpha A_{t+1} (1-\alpha) K_{t+1}^{\alpha-2} \left(S_{\max}\right)^{-1} \\ & \times \left[A_t \left(1 - K_{t+1}\right)^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} - A_t \left(1 - K_{t+1}\right)^{\alpha-1} K_{t+1}\right] \\ & + \beta \alpha A_{t+1} K_{t+1}^{\alpha-1} \left(S_{\max}\right)^{-1} \left[\alpha A_t \left(1 - K_{t+1}\right)^{\alpha-1} + A_t \left(1 - K_{t+1}\right)^{\alpha-1}\right] \end{aligned}$$

is positive, the derivative of the implicit function implies that dK_{t+1}/dA_t has the same sign as

$$-\frac{dG(A_t, A_{t+1}, K_{t+1})}{dA_t} = -\alpha (1 - K_{t+1})^{\alpha - 1}$$
$$+\beta\alpha A_{t+1} K_{t+1}^{\alpha-1} (S_{\max})^{-1} \left[(1 - K_{t+1})^{\alpha} - (1 - K_{t+1})^{\alpha-1} K_{t+1} \right],$$

which is itself positive for

$$S_{\max} < \beta A_{t+1} K_{t+1}^{\alpha-1} (1 - 2K_{t+1}).$$

The same holds for $dF_t/dA_t = \eta dK_{t+1}/dA_t$.

(c) The elasticity of credit growth to *future* productivity growth is always positive no matter whether financial markets are complete or incomplete as only the opportunity cost effect is at work. For $\phi = 0$ the derivative of the implicit function applied to (12) implies

$$\frac{dK_{t+1}}{dA_{t+1}} = -\frac{\frac{dG(A_t, A_{t+1}, K_{t+1})}{dA_{t+1}}}{\frac{dG(A_t, A_{t+1}, K_{t+1})}{dK_{t+1}}} = \frac{\beta K_{t+1}^{\alpha-1}}{(1-\alpha)\left[A_t (1 - K_{t+1})^{\alpha-2} + \beta A_{t+1} K_{t+1}^{\alpha-2} \right]} > 0.$$

For $\phi = 1$, given $dG(A_t, A_{t+1}, K_{t+1})/dK_{t+1} > 0$, the derivative of the implicit function applied to (13) implies that dK_{t+1}/dA_{t+1} has the same sign as

$$-\frac{dG(A_t, A_{t+1}, K_{t+1})}{dA_t} =$$
$$\beta\alpha K_{t+1}^{\alpha-1} (S_{\max})^{-1} \left[A_t (1 - K_{t+1})^{\alpha} + \beta^{-1} A_{t-1} K^{\alpha} - A_t (1 - K_{t+1})^{\alpha-1} K_{t+1} \right],$$

which is always positive. The same holds for $dF_t/dA_{t+1} = \eta dK_{t+1}/dA_{t+1}$.

All these results hold for any A_{t-1}, A_t and A_{t+1}. They therefore apply also to the comparison of our three scenarios: the baseline scenario in which productivity is the same in all periods (i.e. $A_{t-1} = A_t = A_{t+1} = A$) vs. the scenarios in which there is productivity growth from period $t-1$ to period t (i.e. $A_t > A_{t-1} = A_{t+1} = A$) and from period t to period $t+1$ (i.e. $A_{t+1} > A_{t-1} = A_t = A$). As the entrepreneur does not borrow in period $t-1$, dF_t/dA_t and dF_t/dA_{t+1} indeed capture the reaction of credit growth in period t to *contemporaneous* productivity growth and to *future* productivity growth respectively.

Appendix A.3: Estimation of Firm-Level TFP

The starting point of the estimation of firm-level TFP is the standard Cobb-Douglas production function for firm i at time t

$$Y_{it} = A_{it} K_{it}^{\alpha} L_{it}^{1-\alpha}$$

where Y_{it} is real value added, K_{it} is the real book value of net capital, L_{it} is total employment, and A_{it} is TFP.

Estimating TFP using a standard Cobb-Douglas setting is subject to endogeneity problems between the input levels and the unobserved firm-specific productivity. Following Olley and Pakes (1996) and Levinshon and Petrin (2003), the unobserved firm-specific productivity is controlled for by a proxy derived from a structural model. This proxy is a function of capital and material inputs, approximated by a third-order polynomial as in Petrin et al. (2004).

Specifically, the following regression is estimated on a 2-digit industry level using GMM, with the moments restrictions specified as in Woolridge (2009):

$$\begin{aligned} y_{i(t)} &= \beta_0 + \beta_1 k_{i(t)} + \beta_2 k_{i(t-1)} + \beta_3 m_{i(t-1)} + \beta_4 k_{i(t-1)}^2 + \beta_5 m_{i(t-1)}^2 + \beta_6 k_{i(t-1)}^3 \\ &\quad + \beta_7 m_{i(t-1)}^3 + \beta_8 k_{i(t-1)} m_{i(t-1)} + \beta_9 k_{i(t-1)} m_{i(t-1)}^2 + \beta_{10} k_{i(t-1)}^2 m_{i(t-1)} \\ &\quad + \gamma Year_t + \omega l_{i(t)} \end{aligned}$$

All variables are in logs: $y_{i(t)}$ is real value added of firm i in year t, $k_{i(t)}$ is its real book value of net capital, $m_{i(t)}$ is material inputs, $l_{i(t)}$ is total employment, $Year_t$ is a time dummy. While capital is assumed to take time to build, labor and TFP are simultaneously determined, so labor is instrumented by its first lag. TFP is then computed as

$$TFP_{i(t)} = rva_{i(t)} - \left(\widehat{\beta}_0 + \widehat{\beta}_1 k_{i(t)} + \widehat{\gamma} Year_t + \widehat{\omega} l_{i(t)}\right)$$

Two key assumptions of this methodology are that: i) productivity follows a first-order Markov process; and ii) capital is assumed to be a function of past investments and not current ones. These assumptions imply that productivity shocks at time t do not depend on capital at time t, but only on past productivity realizations. They also imply that an increase in bank credit at time t, even if used for investment, does not affect capital at time t as capital needs time to build up.

Appendix A.4: Complete Tables, Baseline Regression by Country

Table 7: France

Elasticity of credit to:	(1)	(2)	(3)	(4)
TFP_t	-0.27***			
	(0.01)			
TFP_{t+1}		0.15***		
		(0.01)		
RVA_t			0.17***	
			(0.008)	
RVA_{t+1}				0.23***
				(0.01)
$Leverage_{t-1}$	-1.88***	-1.93***	-1.88***	-1.90***
	(0.02)	(0.02)	(0.009)	(0.02)
Maximum internally	-0.56***	-0.61***	-0.77***	-0.62***
financed growth	(0.02)	(0.02)	(0.02)	(0.02)
R2	0.03	0.03	0.03	0.03
Observations	590,985	589,600	724,711	624,086

***, **, * Significant at the 1%, 5% and 10% level. As defined in Section 3 *TFP* is total factor productivity and *RVA* is real value added, Leverage is the ratio of total debt on total assets, Maximum internally financed growth is the maximum level of growth reachable without external finance as defined in Guiso et al. (2004) and Higgins (1977). The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7). All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.

Table 8: Germany

Elasticity of credit to:	(1)	(2)	(3)	(4)
TFP_t	-0.08***			
	(0.007)			
TFP_{t+1}		0.06***		
		(0.008)		
RVA_t			-0.001	
			(0.006)	
RVA_{t+1}				0.09***
				(0.007)
$Leverage_{t-1}$	-0.70***	-0.70***	-0.68***	-0.70***
	(0.002)	(0.02)	(0.02)	(0.02)
Maximum internally	-0.002	-0.01	-0.002	-0.008*
financed growth	(0.002)	(0.006)	(0.02)	(0.005)
R2	0.03	0.03	0.03	0.03
Observations	186,015	184,807	267,955	202,574

***, **, * Significant at the 1%, 5% and 10% level. As defined in Section 3 *TFP* is total factor productivity and *RVA* is real value added, Leverage is the ratio of total debt on total assets, Maximum internally financed growth is the maximum level of growth reachable without external finance as defined in Guiso et al. (2004) and Higgins (1977). The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7). All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.

Table 9: Italy

Elasticity of credit to:	(1)	(2)	(3)	(4)
TFP_t	0.02***			
	(0.001)			
TFP_{t+1}		0.02***		
		(0.001)		
RVA_t			0.11***	
			(0.003)	
RVA_{t+1}				0.001
				(0.005)
$Leverage_{t-1}$	-1.21***	-1.23***	-1.22***	-1.22***
	(0.008)	(0.008)	(0.003)	(0.008)
Maximum internally	-0.17***	-0.10***	-0.28***	-0.11***
financed growth	(0.009)	(0.01)	(0.01)	(0.01)
R2	0.05	0.04	0.06	0.04
Observations	1,721,881	1,705,251	2,322,067	1,844,144

***, **, * Significant at the 1%, 5% and 10% level. As defined in Section 3 *TFP* is total factor productivity and *RVA* is real value added, Leverage is the ratio of total debt on total assets, Maximum internally financed growth is the maximum level of growth reachable without external finance as defined in Guiso et al. (2004) and Higgins (1977). The elasticities are computed separately by country at time t and $t+1$ using equations (6) and (7). All specifications include controls, time dummies, and firm fixed effects. Standard errors are clustered at the sector level.