Banks Credit and Productivity Growth *

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Abstract:

In advanced economies domestic credit to private non-financial corporations is about 90% of GDP. The allocation of such large amount of funds is of critical importance to the success of an economy and the financial sector plays a key role in allocating capital efficiently. In this paper we focus more explicitly on the link between bank credit and firm-level productivity from both a theoretical and empirical perspective. We introduce a model of overlapping generations of entrepreneurs that need to invest in either short-term and long-term capital where the trade-offs arise from expectations on productivity growth between the short- and long-term, the presence of a credit constraint, and a shock that can hit the long-term investment. We derive the relation between credit and either contemporaneous and future productivity growth under complete and incomplete credit markets. Then, we investigate the main predictions of the model exploiting a novel firm-level data set that offers granular and comparable measures of productivity and bank credit for France, Germany and Italy. We estimate an extended set of elasticities of bank credit with respect to a series of productivity measures of firms. Following the main derivations of the model we focus not only on the relation between bank credit and productivity during the same year, but also between credit and future productivity. Our estimates show a Eurozone core-periphery divide, the estimations of France and Germany are consistent with complete markets, whereas in Italy they are consistent with incomplete markets. The implication is that credit allocation in Italy turns to be suboptimal to the productivity patterns expected by firms with respect to France and Germany. Hence capital misallocation by banks can be a key driver of the long-standing slow productivity growth that characterises Italy and other periphery countries.

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1 Introduction

In advanced economies domestic credit to private non-financial corporations is about 90% of GDP. The allocation of such large amount of funds is of critical importance to the success of an economy and the financial sector plays a key role in allocating capital efficiently. This implies that banks should invest capital in the firms that are expected to have higher returns and withdraw it from those with poor prospects. The q-theory of investments offers a traditional benchmark to identify such firms by looking at the ratio of the market value of a firm's existing assets to the replacement cost of the firm's physical assets. The market value of firm's assets should already account for firm's expected productivity, so an efficient allocation of bank credit should deliver the highest productivity growth that an economy can achieve (holding everything else constant). However, in practice a firm's market value do not reflect only expected productivity gains and not all firms are listed, so for them it can be harder to assess their market value. In this paper we focus more explicitly on the link between bank credit and firm-level productivity from both a theoretical and empirical perspective.

Our point of departure is a theoretical model, which examines the relationship between productivity and bank credit in the context of different financial market set-ups. The model is a two-periods OLG model of entrepreneurs and credit under both complete and incomplete markets close in spirit to the one of Aghion et al. (2010). Entrepreneurs are born with a stock of human capital that they transform into a combination of short-term and long-term capital. The former is used for goods that are produced and sold in the first period, so the entrepreneur can pay for it within the same period. Whereas, long-term capital is going to be used for production in the second period, so the entrepreneur needs credit for long-term investment. The trade-off between the two-types of capital comes from the expected productivity growth between the two periods, the credit constraint that the entrepreneur can face, and a liquidity shock that can hit the long-term capital at the end of the first period before that it is put into production.[1] With complete credit markets the liquidity shock is not biding, as the en-

[1] For instance we can think about the success associated to a long-term R&D project which can partly go wrong and deliver lower long-term capital than expected.

trepreneur can borrow enough to meet such shock, which does not affect the optimization problem.[2] Under this scenario the model predicts that if firms expect productivity to increase in period t relative to period $t+1$, the entrepreneur has an incentive to invest more in short-term capital relative to the long-term one, thus decreasing her level of borrrowing. Therefore, as we will see more in details, the complete markets model predicts a negative correlation between bank credit and a contemporaneous productivity growth and a positive one between bank credit and future productivity growth. Under incomplete markets though, the liquidity shock is binding. In this case, if productivity is expected to increase at t relative to $t+1$, it rises the entrepreneur's possibility to meet the liquidity shock, so this may increase her level of borrowing for long-term capital leading to a positive correlation between contemporaneous productivity growth and bank credit. Whereas, under incomplete markets, the model predicts a positive correlation between future productivity growth and borrowing although of lower magnitude with respect to the complete market case.

Then, we analyse the predictions of the model relying on firm-level data of bank loans and productivity for a set of Eurozone countries. We use the ECB-CompNet database, which provides data on bank credit from firms' balance sheet matched with various firm-level measures of productivity, such as total factor productivity, marginal product of capital, labor productivity and also real value added. We use these data by country in order to document the joint distribution of credit and productivity and to estimate the correlation between bank credit and firm's productivity growth. In particular, to be consistent with the model, we look at the correlation between bank credit growth at time t and productivity growth at either time t and $t+1$. We do so controlling for a proxy of credit demand using a measure of external financial needs at the firm level, firm's financial health, as well as sector, year, and firm fixed effects. Moreover, we analyse the heterogeneity of such estimates by firm-size. The results show a divide between the Eurozone core and periphery. France and Germany have large and negative coefficients between credit and productivity growth at time t, whereas Italy

[2] We can think about this case as if banks can offer an insurance contract against the liquidity shock when giving credit.For instance this may be linked to banks' ability to securitize the loans they issue.

has a positive one. Moreover, even if all countries have a positive coefficient between credit and productivity growth at time *t+1*, in Italy it is significantly smaller than in the other countries. If we read these results through the lenses of our model, it follows that France and Germany resemble the predictions of the model under a complete market setting, whereas in Italy it matches the predictions under incomplete markets. This implies that the allocation of credit in Italy is suboptimal with respect to France and Germany and it leads to a lower aggregate productivity growth.

The paper relates to the literature that analyses the effects of finance on economic growth (King and Levine, 1993; Levine, 1997; Rajan and Zingales, 1998; Guiso et al., 2004; Levine, 2005; Ciccone and Papaioannou, 2006; Beck et al., 2008); to the literature on the real effects of bank credit such as Jimenez et al. (2014), Chodorow-Reich (2014), Schnabl (2012), Amiti and Weistein (2011) and Khawaja and Mian (2008); and to the literature on resource misallocation in Europe like Gopinath et al. (2015). However, the paper closest in spirit to ours is Wurgler (2000) which specifically assess the role of the financial sector in allocating capital efficiently. This study takes the sector-level elasticity of investment on value added as a measure of the allocative efficiency of capital and then rely on cross-country reduced form regressions to evaluate the impact of different financial factors on such measure.[3] Hartmann et al. (2007) extend the work of Wurgler by looking at the impact that different characteristics of the financial sector have on the volume of investments.[4] Lee et al. (2016) follows an approach similar to Wurgler (2000) focusing on a longer sample period for the US.

The contribution of the paper is to focus explicitly on the link between credit allocation and productivity growth. We do not look at the effects of credit constraints on firm's growth, but rather if bank credit is allocated optimally given the productivity growth that firms expect. We do so by introducing an OLG model of credit allocation with complete and incomplete

[3] Wurgler (2000) regresses this elasticity on the level of financial development measured as the sum of stock market capitalization and private and non-financial public domestic credit.

[4] They develop 17 indicators of different aspects of the financial system that can be mainly grouped into size, innovation and completeness, transparency, corporate governance, regulation, and competition.

markets, which provides clear guidance about the relation between credit and productivity at different points in time. The second contribution of the paper is to estimate the correlations implied by the model using a novel firm-level dataset across a set of eurozone countries, that provides granular firm-level information on both finance and productivity normally not available, especially in a comparable way across countries. This allows us to present a comprehensive set of measures on the relation between bank credit and productivity at the firm-level since the late 1990s for a group of Eurozone countries. The paper is structured as follow: in Section 2 we introduce the theoretical model that serves us as a guide to interpret and test the interaction between bank credit and productivity; Section 3 presents the empirical specifications. Section 4 discusses the main results and policy implications; and Section 5 concludes.

2 A model of Credit and Productivity

Our point of departure is a model of investment in the spirit of Aghion, Angeletos, Banerjee and Manova (2010), in which an entrepreneur chooses between short- and long-term capital goods. The main ingredients of the model are i) that borrowing is needed for investing in long-term capital, ii) there is a simple borrowing constraint which is a share of contemporaneous income, iii) there is a liquidity shock that can disrupt long-term investment, iv) credit markets can be complete, such that the liquidity shock does not affect the entrepreneur's investment optimization, and incomplete markets where the liquidity shock is biding. In this framework firm's investments between short-term and long-term capital depends on the expected productivity growth between the two period (an "opportunity cost effect") and on the entrepreneur's ability to meet the liquidity shock if it occurs ("liquidity shock effect"). In this section we derive the relation between bank credit and contemporaneous and future productivity growth under complete and incomplete markets. This will offer theoretical guidance to the empirical analysis that we undertake in the next section of the paper.

2.1 Production, Investment and Capital Goods

Consider an entrepreneur who can be active for at most two periods, t ('short run') and $t+1$ ('long run'), and maximizes the present expected value of flow profits over the two periods.[5] The entrepreneur is endowed with $L_t = L_{t+1} = L$ units of labor in both periods, and H_t units of human capital. Human capital can be thought of as skills and other know-how that the entrepreneur decides to invest in the first period for the creation of both short-term and long-term capital.

The technologies for transforming human capital in capital goods are assumed to be linear and to share the same productivity θ_t with the supplies of the short- and long-term capital goods given by $K_t = \theta H_{k,t}$ and $Z_t = \theta H_{z,t}$ respectively, where $H_{k,t}$ and $H_{z,t}$ are the amounts of human capital used as inputs for the two goods ($H_{k,t} + H_{z,t} = H_t$, or equivalently $K_t + Z_t = \theta H_t$). Short-term capital K_t can be installed quickly and can be used for production at t. Whereas, long-term capital Z_t needs time to build up and can be used for production only at $t+1$; we can think about this as capital that results from research&development and longer term investments.

Turning to the production of the final good, in period t the entrepreneur supplies this good combining her first-period labor endowment L_t with the installed amount of the short-term capital good K_t through the Cobb-Douglas technology

$$Y_t = A_t K_t^{\alpha} L^{1-\alpha},$$

where: Y_t is the final good output; $A_t \in [A_{\min}, A_{\max}]$, with $0 < A_{\min} < A_{\max} < \infty$, is TFP; and $\alpha \in (0,1)$ is the income share of the short-term capital good. Analogously, in period $t+1$ the entrepreneur supplies the final good combining her second-period labor endowment with the installed (and tooled) long-term capital good Z_t through the Cobb-Douglas technology

$$Y_{t+1} = A_{t+1} Z_t^{\alpha} L^{1-\alpha},$$

where: Y_{t+1} is the final good output; $A_{t+1} \in [A_{\min}, A_{\max}]$ is TFP; and $\alpha \in (0,1)$ is the income share of the long-run capital good.

[5] While, for realism, we could have more than two periods, two will make the logic of the argument more transparent.

2.2 Borrowing and Credit Constraint

We assume that the entrepreneur can only borrow from and lend to banks at an exogenously (risk-free) rate R_t. The entrepreneur faces an ad-hoc borrowing constraint such that her net borrowing in period t cannot exceed a multiple $\mu \geq 0$ of her contemporaneous income. Moreover, the investment in long-term capital is subject to a liquidity shock, such that the project might turn unsuccessful and hinder the ability to repay the loan. When credit markets are sufficiently tight the entrepreneur is not able to meet the maximum liquidity shock and the borrowing constraint is binding (i.e. μ is sufficiently small).[6]

Under these assumptions, the budget and borrowing constraints (when relevant) of the entrepreneur in period t can thus be stated as

$$\Pi_t + q_t(K_t + Z_t) + S_t e_t = Y_t + B_t, \qquad B_t \leq \mu Y_t, \tag{1}$$

where: Π_t is profit in period t; q_t is the unit (shadow) price of capital goods; $q_t(K_t + Z_t)$ is expenditures on capital goods; S_t is the liquidity shock; e_t is an indicator function valued 1 if the entrepreneur covers the liquidity shock and 0 otherwise; B_t is borrowing (or lending, if negative); and Y_t is revenue (as the price of the final good is normalized to one). Differently, as in the second period the entrepreneur cannot borrow (being this her last period of activity), her budget constraint in period $t+1$ is given by

$$\Pi_{t+1} + (1 + R_t)B_t = [Y_{t+1} + (1 + R_t)S_t]\, e_t, \tag{2}$$

where $(1+R_t)B_t$ is borrowing and associated interest repayment (or lending and associated interest repayment if B_t is negative) and $(1 + R_t)S_t$ is the recovery of the tooling cost with interest.

[6]The formal condition for this to happen is $s_{\max} > A_{\max}\theta^{\alpha}\left(L_t/H_t\right)^{1-\alpha}$, where $s_{\max}$ is the maximum liquidity shock that can hit the entrepreneur. This condition states that, even after devoting (in the limit) all human capital to the production of the short-term capital good and achieving maximum productivity in the first period, the entrepreneur would not generate enough income in that period to meet the maximum possible realization of the liquidity shock.

2.3 Productivity Shocks and Borrowing Response

The present expected value of the flow of profits is given by

$$\Pi_t + (1 + R_t)^{-1} E_t[\Pi_{t+1}] \tag{3}$$

To understand how borrowing reacts to productivity shocks, we characterize the composition of investment that maximizes the present expected value of the entrepreneur's flow profits in our two scenarios: when the credit market is complete so that credit constraints are not binding; and when it is incomplete so that credit constraints are binding.

2.3.1 Complete Credit Market

When the credit market is complete, the entrepreneur can borrow as much as she wishes in the first period of her life. She can thus meet the liquidity shock, as the net present value of meeting the liquidity shock is positive:

$$(1 + R_t)^{-1} [Y_{t+1} + (1 + R_t)S_t] - (1 + R_t)^{-1} S_t = (1 + R_t)^{-1} Y_{t+1} > 0.$$

The fact that it is always optimal for the entrepreneur to meet the liquidity shock implies that she always sets $e_t = 1$. With this result at hand, we can use the budget constraints (1) and (2) to substitute for Π_t and Π_{t+1} in (3) so as to write the entrepreneur's maximization problem

$$\max_{k_t, z_t} A_t k_t^{\alpha} l_t^{1-\alpha} + (1 + R_t)^{-1} E_t \left[A_{t+1} z_t^{\alpha} l_t^{1-\alpha} \right] - q_t k_t - q_t z_t$$

subject to

$$k_t - z_t = \theta,$$

where $l_t \equiv L_t/H_t$, $k_t \equiv K_t/H_t$ and $z_t \equiv Z_t/H_t$ denote the 'normalized' levels of L_t, K_t and Z_t while $k_t - z_t = \theta$ comes from the technology and resource constraints for capital goods production requiring $K_t + Z_t = \theta H_t$.[7]

The first order conditions of this problem with respect to k_t and z_t then imply that the marginal products of short- and long-term capital goods are

[7] By assumption, the normalized level of labor $l_t \equiv L_t/H_t$ is exogenously given.

equalized in present expected value

$$\alpha A_t (\theta - z_t)^{\alpha-1} l_t^{1-\alpha} = (1+R_t)^{-1} E_t \left[\alpha A_{t+1} z_t^{\alpha-1} l_t^{1-\alpha}\right].$$

Rewriting this condition as

$$\left(\frac{z_t}{\theta - z_t}\right)^{1-\alpha} = (1+R_t)^{-1} \frac{E_t\left[A_{t+1}\right]}{A_t} \tag{4}$$

reveals that, as R_t is exogenously given, larger A_t leads to smaller z_t whereas larger $E_t\left[A_{t+1}\right]$ leads to larger z_t. In other words, *when the credit market is complete the correlation between borrowing and contemporaneous productivity growth is negative whereas the correlation between borrowing and future productivity growth is positive.* This is a standard 'opportunity cost effect': if productivity increases in period t (period $t+1$) relative to period $t+1$ (period t), the entrepreneur has an incentive to increase the supply of the short-term (long-term) capital good relative to the long-term (short-term) capital good, thus decreasing (increasing) her level of borrowing.

2.3.2 Incomplete Credit Market

Consider now the case in which the credit market is incomplete. As before, if the entrepreneur can borrow enough funds to meet the liquidity shock in the first period, she will find it optimal to do so. However, differently from before, the entrepreneur now faces a credit constraint, because in the first period she can borrow at most a fraction μ of her contemporaneous income; thus, there is uncertainty about whether she will be able to meet the liquidity shock. This implies that the maximum liquidity available to the entrepreneur in period t equals $(1+\mu)Y_t$ and she meets the liquidity shock if and only if $S_t \leq (1+\mu)Y_t$. Accordingly, given our distributional assumption on s_t, the entrepreneur meets the liquidity shock with probability $\Phi_t \equiv \Phi((1+\mu)(Y_t/H_t)) = \left[(1+\mu)A_t k_t^{\alpha} l_t^{1-\alpha}/s_{\max}\right]^{\phi}$, and faces 'failure' or 'liquidation' of her long-term investment with probability $1-\Phi_t$ ('liquidity risk').

Using the budget constraints and borrowing (1) and (2) to substitute for Π_t and Π_{t+1} in (3), we can state the entrepreneur's problem with incomplete credit market as:[8]

$$\max_{k_t, z_t} A_t k_t^{\alpha} l_t^{1-\alpha} + (1+R_t)^{-1} E_t \left[\Phi_t A_{t+1} z_t^{\alpha} l_t^{1-\alpha} \right] - q_t k_t - q_t z_t$$

subject to

$$k_t + z_t = \theta.$$

The first order conditions of this problem with respect to k_t and z_t now require the equalization of the marginal product of the short-term capital with the liquidity-risk-adjusted marginal product of the long-term capital (in present expected value), such that:

$$\alpha A_t (\theta - z_t)^{\alpha-1} l_t^{1-\alpha} + (1+R_t)^{-1} E_t \left[\frac{\partial \Phi_t}{\partial k_t} A_{t+1} z_t^{\alpha} l_t^{1-\alpha} \right] = (1+R_t)^{-1} E_t \left[\alpha \Phi_t A_{t+1} z_t^{\alpha-1} l_t^{1-\alpha} \right] + (1+R_t)^{-1} E_t \left[\frac{\partial \Phi_t}{\partial z_t} A_{t+1} z_t^{\alpha} l_t^{1-\alpha} \right]$$

or equivalently

$$\left(\frac{z_t}{\theta - z_t} \right)^{1-\alpha} = (1-\tau_t)(1+R_t)^{-1} \frac{E_t [A_{t+1}]}{A_t} \tag{5}$$

with

$$\tau_t \equiv 1 - \Phi_t + \left(\frac{\partial \Phi_t}{\partial k_t} - \frac{\partial \Phi_t}{\partial z_t} \right) \frac{z_t}{\alpha}.$$

If the credit constraint were not binding, the entrepreneur would meet the liquidity shock with certainty, which implies $\Phi_t = 1$ and $\partial \Phi_t / \partial k_t = \partial \Phi_t / \partial z_t = 0$. In this case τ_t would equal one and (5) would coincide with (4): the choice between short- and long-term capital goods would only depend on the opportunity costs of production. When, instead, the credit constraint binds, whether the entrepreneur can meet the liquidity shock is uncertain and depends on the realisation of the shock. In this case, we have $\Phi_t < 1$, $\partial \Phi_t / \partial k_t > 0$ and $\partial \Phi_t / \partial z_t < 0$ so that, given the definition of Φ_t, τ_t

[8] With $e_t = 1$ and binding credit constraint $B_t = \mu Y_t$, (1) and (2) become $\Pi_t + q_t(K_t + Z_t) + \Phi_t S_t = Y_t (1+\mu)$ and $\Pi_{t+1} + (1+R_t)\mu Y_t = \Phi_t [Y_{t+1} + (1+R_t) S_t]$ respectively.

evaluates to

$$\tau_t = 1 - \left[\frac{(1+\mu) A_t (\theta - z_t)^{\alpha} l_t^{1-\alpha}}{s_{\max}} \right]^{\phi} \left(1 - 2\phi \frac{z_t}{\theta - z_t} \right). \tag{6}$$

This shows that the incompleteness of the credit market works as a 'tax' τ_t on the return of investment in the long-term capital good due to the fact that this investment has a positive probability of failure. This probability increases with the supply of the long-term capital good, as larger supply of that good drains the income from short-term production that can be used to meet the liquidity shock, both directly and indirectly as collateral for (constrained) borrowing. For given z_t, the 'tax' τ_t is higher when the credit constraint is more severe (smaller μ), when the probability of a sizeable liquidity shock is higher (larger $s_{\max}$ or larger ϕ), and when the productivity of capital goods production is lower (smaller θ).

For our purposes, however, the crucial aspect of the 'tax' in (6) is that it depends on the (expected) productivity of final good production in the two periods, both directly through A_t as well as $E_t[A_{t+1}]$ and indirectly through z_t. Accordingly, the entrepreneur's choice between short- and long-term capital good supply depends not only on the opportunity costs of production (i.e. $(1+R_t)^{-1}(E_t[A_{t+1}]/A_t)$) but also on a 'wedge' (i.e. $(1-\tau_t)$) introduced by the 'tax' between the marginal products of short- and long-term capital goods. To see what this implies, we can substitute (6) in (5) to obtain the profit-maximising implicit relation of investment, z_t, with current and expected future productivity levels, A_t and $E_t[A_{t+1}]$:

$$\left(\frac{z_t}{\theta - z_t} \right)^{1-\alpha} = \left\{ \left[\frac{(1+\mu) A_t (\theta - z_t)^{\alpha} l_t^{1-\alpha}}{s_{\max}} \right]^{\phi} \left(1 - 2\phi \frac{z_t}{\theta - z_t} \right) \right\} (1+R_t)^{-1} \frac{E_t[A_{t+1}]}{A_t} \tag{7}$$

This relation is analyzed graphically in Figure 1. In the figure the left and right hand sides of (7) are plotted against investment z_t measured along the horizontal axis. In particular, the left hand side (LHS) is represented by the upward sloping curve starting from the origin while the right hand side (RHS) is represented by the downward sloping curve meeting the horizontal axis at $z_t = \theta / (2\phi + 1)$. The optimal level of investment z_t^* corresponds to the crossing of the two curves. Given the slopes and the intercepts of the two curve, this level is unique.

What is the impact of higher expected productivity in period $t+1$ on borrowing in period t? Larger $E_t[A_{t+1}]$ does not affect the left hand side, whereas it rotates the right hand side clockwise to RHS'. It follows that the optimal level of investment z_t^* and thus borrowing in period t increase. As in the case of complete credit market, higher expected productivity in the second period always entails more production of the long-term capital good in the first period. Hence, *the correlation between borrowing and future productivity growth is positive also when the credit market is incomplete. However, this correlation is lower with respect to the complete market case because of the liquidity risk.* To put it differently, under incomplete market if firms expect higher future productivity growth, they will borrow and invest in long term capital, but will do so by a lower degree than under complete markets.

What about the impact of higher productivity in period t on borrowing in that period? In principle, the answer depends on two opposite effects. The first is the 'opportunity cost effect' that is also present with complete credit market. It works through the rise in the relative current productivity $E_t[A_{t+1}]/A_t$ and makes the entrepreneur decrease the supply of the long-term capital good in favor of the short-term one. The second effect is the 'liquidity risk effect' that works through the increase in the probability of covering the liquidity shock $\Phi_t = \left[(1+\mu)A_t(\theta - z_t)^\alpha l_t^{1-\alpha}/s_{\max}\right]^\phi$: all the rest equal, larger A_t allows to meet larger shocks, so it encourages borrowing and investment in long-term capital even if the firm is experiencing higher contemporaneous productivity. Which of the two effects dominates hinges on the comparison between ϕ and 1 given that the change in Φ_t is proportionate to A_t^ϕ while the change in productivity ratio is proportionate to A_t^{-1}. Under our assumption on the distribution of the shocks, it turns that $\phi > 1$ and the 'liquidity risk effect' dominates. For $\phi > 1$, the increase in Φ_t associated with larger A_t is strong, because the density of the liquidity shock distribution is disproportionately concentrated close to the upper bound of its support. As a result, for $\phi > 1$, the right hand side of (7) rotates clockwise to RHS' as A_t rises, leading to more investment on long-term capital goods and thus more borrowing. Accordingly, higher productivity in the first period entails more production of the long-term capital good in that period. Hence, differently from when the credit market is complete, *the correlation between borrowing and contemporaneous productivity growth is positive when the credit market is incomplete.*[9]

3 Empirical Analysis

In this section we analyse the relation between bank credit and productivity across different Eurozone countries through the lenses of our model. The purpose is to check whether the predictions of the model have an empirical correspondence, so to investigate the degree of credit market completeness that can affect credit allocation across countries.

3.1 The dataset

We use a novel firm-level data set, based on the CompNet database of the ECB.[10] One of the main advantage of this source is that it provides comparable estimates of firm-level characteristics across a set of European countries, since variable definitions and data treatment are carefully homogenised across the participant country. The firm-level data we are using are not pooled at the sector level, but they are separately managed by the individual national statistical offices. In Table 1 we provide a summary of the specific data source and sample extension of the countries we use in this paper.

For each firm we have data on bank credit, leverage, return on assets, total factor productivity, marginal product of capital, labor productivity, and

[9]Beyond our assumption, for $\phi = 1$ the 'opportunity cost effect' and the 'liquidity risk effect' exactly offset each other; while for $\phi < 1$ the 'opportunity cost effect' dominates. The reason why for $\phi < 1$ the increase in Φ_t associated with larger A_t is weak is that the density of the liquidity shock distribution is disproportionately located close the lower bound of its support. As a result, for $\phi < 1$ the right hand side of (7) would rotate counterclockwise as A_t rises, leading to less investment in the long-term capital good and thus less borrowing. Accordingly, even when the credit market is incomplete, the impact of higher productivity in the first period on the production of the long-term capital good in that period would still be negative if the entrepreneur were more likely to be exceptional than standard at solving tooling problems.

[10]See Lopez-Garcia and di Mauro (2015) for details about the CompNet dataset.

real value added. For financial data, bank credit corresponds to the entry "liabilities to financial institutions" in the firms' balance sheet. Returns on assets are defined as operating profit/loss over the average of total assets. Finally, leverage is the ratio of total debt on total assets.

As for data on productivity, the CompNet Database computes the firm-level TFP using the approach of Wooldridge (2009), which follows Olley and Pakes (1996) and Levinshon and Petrin (2003) to deal with the problem of endogeneity between TFP and inputs (see the Appendix for details about the TFP estimation). The marginal product of capital is defined as the ratio of real value added over the 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.

3.2 Econometric specifications

We run a series of firm level regressions in reduced form that follow the intuitions of the main derivations of the model in Section 2. The regressions are implemented separately by country. Our approach turns out to be similar to Wurgler (2000), who regress the growth rate of investments - as a proxy for credit - on the growth rate of value added - as a measure of investment opportunity - at the industry level. He estimates the elasticity of investment with respect to real value added as a proxy of the elasticity of credit with respect to investment opportunity, which is consistent with a q-theory of investment as it captures whether credit get reallocated more quickly to the most promising firms.

Our framework allows us to do go deeper into this type of analysis as we look directly at bank credit at the firm level and focus explicitly on firm's productivity. We regress the growth rate of bank credit on the growth rate of firm's total factor productivity. Following the main derivations of the model we do so by looking at bank loans at time t with respect to productivity growth at either time t and $t + 1$ (at yearly frequency). Moreover, in order to offer a more comprehensive analysis and exploit fully our dataset, we look also at other measures of productivity such as the marginal product of capital, labor productivity, and also real value added. Finally, we also extended the analysis at $t+2$ so we look.

Equation 8 below is our main specification. We control for a proxy of external finance demand, financial health of a firm, year, sector, and firm fixed effects.[11] In addition to the baseline specification we run (8) for firms below and above 50 employees, so we can compare the differences between large and small firms.

$$\begin{aligned} Credit\ Growth_{ist} = \beta_0 + \beta_1 Productivity\ Growth_{ist+k} + \\ \beta_2 Growth\ with\ internal\ funds_{ist} + \beta_3 Leverage_{ist-1} + \delta_t + \gamma_s + \psi_i + \epsilon_{ist} \end{aligned} \tag{8}$$

where the dependent variable is the growth rate of credit (loans and bonds) of firm i in sector s at time t; the explanatory variable of interest is productivity growth at time $t+k$, $k = 0, 1, 2$; we use different productivity measures alternatively at various points in time $t+k$; δ_t is a year dummy; γ_s is a sector dummy; ψ_i is a firm dummy, and ϵ_{ist} is the error term.

We put bank credit on the left-hand side, because - although there is an extensive literature that investigate the impact that credit constraints on firm's productivity itself - the purpose of our research and model is to understand the allocation of credit and its relation to firm's productivity.

The measures of productivity enter in the regression at time t, $t+1$ and $t+2$. These are realised productivities, which are equal to expected productivities under the assumption that banks and markets have rational expectations with perfect foresight. If these assumptions are violated realised productivities are not equal to the expected ones, so we have measurement error in the independent variable of interest. Nevertheless, this measurement error would generate an attenuation bias in our estimates, so our results would provide a lower bound of the true elasticities for each country and a lower bound of the elasticity differences across countries. It is important to stress that we do not give to our estimates causal interpretation, as they might subject to endogeneity issues, but they capture the relation of bank credit

[11] As robustness, we have run a specification with sector-year fixed effects. The results barely change, but computation time is more efficient with year and sector dummy entering separately.

with respect to contemporaneous and future productivity growth in a way that we can interpret through the derivation of the model.

Notice, that in our dataset bank lending information des not come from the banks' balance sheets, but rather from firms' balance sheet that declare their liabilities towards financial instituions. However, the sample of firms is large and representative, so our results can be representative of the aggregate banking activity towards non-financial private corporations.

In order to control for firm's financial health, we use leverage. This measure enters at time $t-1$ and not t to avoid endogeneity, given that loans and bonds enter the numerator of leverage. We expect a negative coefficient on this variable as banks and markets will be less willing to provide capital to firms in worse financial conditions.

Finally, if we want to interpret the results in (8) as an elasticity of credit *allocation*, we need to isolate the supply effect from the demand effect. We cannot observe directly the firm's demand for credit, but we account for the external financial needs of a firm. To do so we rely on the maximum rate of internally financed growth following the 'percentage of sales' approach to financial planning as in Guiso et al. (2004), and Higgins (1977).[12] This captures the fact that credit would be demanded for the growth in excess to the one that could be internally financed. We expect the coefficient β_2 to be negative and significant as firms with higher growth through internal resources will demand less credit and hence they will be negatively correlated with credit allocation.[13] Moreover, we also have firm fixed effects that control for time-invariant firm characteristics and, as Khwaja and Mian (2008) show, these firm fixed-effects capture overall firm-level credit demand due

[12]This will depended on return to assets. Specifically Financial demand$_{ist}$ $= 1 -$ Maximum rate of internally financed growth $= 1 - \frac{ROA}{1-ROA}$. This is a micro-founded measure introduced by Higgins (1977).

[13]We do not control for alternative sources of external finance. Data on issued shares are unavailable for most countries and involves a low number of firms. Data on bonds are used as a dependent variable in a separate regression (results available upon request) rather than as an additional control in the specification with loans. This should not bias our results given the small number of firms that issue bonds in the countries of our sample. They do not exceed the 1.5% of firms and observations in all countries, with the exception of Germany where about 25% of firms issue bonds; this might generate an omitted variable bias for the coefficients on Germany.

to time invariant characteristics.

4 Empirical Results

Table 2 presents our main results. We show the coefficients of bank credit growth regressed on various measures of productivity growth by country at t, *t+1*, and *t+2*. The main pattern in the data is that there is a significant and negative correlation between credit and productivity at time t and a positive one at time *t+1* and *t+2*. This is fully in line with our model. Italy is a notable exception to this pattern as it has a positive correlation between credit and total factor productivity (as well as labor productivity) at time t, and a positive, but relatively small in magnitude coefficient in subsequent periods. In all countries the coefficients for $t+2$ tend to be smaller than the ones for $t+1$, but this is because the growth rate of our regressors at time $t+2$ is taken with respect to $t+1$. So, for example, if a new project financed by loans at time t increases productivity at time $t+1$, we will not see a significant correlation between loans at time t and the productivity growth at $t+2$, as it is the case for Germany.

Turning to an interpretation of our empirical results with the model predictions, Germany and France show a set of correlations that is consistent with the complete market setting highlighted in the model. On the contrary in Italy , credit markets would be "incomplete". The small magnitude of the correlation between bank credit and productivity at time $t+1$ would suggest that banks would be affected by some sort of 'short-termism', whereby funds are preferably allocated to projects to immediate short term returns, rather than initiatives, possibly more risky, but that would imply - if chosen correctly - higher future returns and thus higher firm productivity in the following period. Moreover, the positive correlation between bank credit and productivity growth at time t suggests that firms obtain credit based on their current productivity performance without accounting enough for the expected future productivity pattern. In other words, the pattern of correlations we observe in the data suggests that*credit allocation is more of an issue in Italy than in the other countries in our sample.* This result implies that during the last fifteen years bank credit in Italy may have constrained the optimal investments' pattern of firms. This would result in a misallocation of resources and is consistent with the findings on misallocation of Calligaris et al. (2016) and the level of non-performing loans that characterize Italy.

A key point of our results is to understand whether the negative correlation between total factor productivity and credit at time t is just a mechanical consequence that stems from the TFP estimation or if it has a genuine economic interpretation as highlighted in our model. If a firm has a positive productivity shock at t, then it is likely to invest, possibly through accessing credit and increasing capital and labor already at time t. This would bias a standard estimate of TFP coming from a Cobb-Douglas production function and mechanically generates a negative correlation between credit and productivity.However, i) the TFP estimates we rely on control for this simultaneity issue[14] and ii) capital should respond to the positive productivity shock by an amount so large to push a downward bias of the estimate of TFP growth into negative territory, which is implausible given the magnitude of the increase that would be required and the fact that capital needs time to be put in place. Finally, this negative correlation does not involve only the TFP but also alternative measures of productivity such as labor productivity and the marginal product of capital. Therefore, this seems to be a genuine feature of the data generating process.

We look also at differences between large and small firms.[15] Tables 3 shows that qualitatively the baseline results are confirmed across firm size for all measurers and countries. The notable exception is large firms in Italy where the correlation between bank credit and productivity at t turns negative and significant, which resembles the complete market prediction; but the one at $t + 1$ is not statistically different from zero, which confirms the 'short-termism' of access to credit also for large firms in Italy. Moreover, the results show significant differences in the magnitude of the coefficients between small and large firms, as the elasticity of loans to productivity is inversely correlated with firm size. In other words bank credit might get reallocated to more productive firms more quickly among small rather than large firms.

[14]See the Appendix for details on how TFP is estimates in our data.

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

Several interpretation are possible. First, there might be a selection issue due to relational banking; given that large firms are cross-selling clients for whom loans represent only one of the financial services they may ask, banks can choose to finance also less promising projects for such firms as the overarching business relation is still profitable. Even if this can still be optimal from a bank perspective, it has macroeconomic implication in terms of capital allocation towards its most productive uses. Second, it could well be that larger firms are less dependent from bank loans (and related conditions applied by the banks), given their larger access to capital markets, typically unavailable for smaller firms. Third, it could also be that the average commitment and complexity of loans to larger firms is bigger; hence, it might be more complicated to reallocate credit across large firms than small firms.

Large firms represent a big share of employment and value added in an economy. This implies that the allocation of credit towards the more productive firms among large firms is particularly important for the long-term prosperity and productivity growth. Therefore, policy makers should pay particular attention to the degree of credit reallocation among large firms, as our empirical findings suggest that the elasticities are lower than what they could be in comparison with small firms. Possible policy recommendations include exploring the possibility to reduce the concentration limits of banks for loans to specific firms. This might provide incentives for firms to increase the number of lenders for large projects, hence reducing the commitments that a single bank face and easing a relocation of credit towards other firms. Moreover, the regulator could consider demanding a higher weight of specific productivity measures in the risk assessment models that banks use for lending. This would provide an incentive for banks to lend to more productive firms reducing the level of credit misallocation. Such requirement could also be confined to large firms only, for which the information needed to compute productivity measures such as TFP could be more easily available.

5 Conclusions

In this paper we focus on the relationship between bank credit and productivity at the firm level. To study this issue we propose a model of overlapping generations of entrepreneurs, which invest in capital building in the context of two opposite credit markets set-ups, one complete and the other incomplete. The model suggests that the sign and magnitude of the correlation between bank loans and productivity gorwth varies in accordance with the market set-up which prevails. The surprising feature of the model is that it predicts a negative correlation between bank credit and contemporaneous productivity growth under complete credit markets and a positive one under incomplete markets. Moreover, the model predict a positive correlation between bank credit and realised future productivity in both market settings, although of smaller magnitude under incomplete markets.

In the empirical analysis we put this hypothesis at a test, using a novel firm-level data set for a number of EU countries. To do so, we estimate the elasticity of bank credit with respect to various measures of productivity at different points in time, as we look at the between credit and productivity growth as well as between credit and realised future productivity growth. The general pattern of the data is such that there is a strong negative elasticity between contemporaneous bank credit and productivity and a positive one between bank credit and realised productivity in subsequent periods. Italy is a notably exception to this pattern as it shows a positive elasticity also between contemporaneous credit and productivity and quite a positive but small one with respect to future productivity growth.

Reading these results with the eye of the theoretical model suggests that overall - for core European countries considered - financial markets appear to be approaching the "complete" state as defined by the model, although with different degrees of "completeness" across countries. On the other hand, for Italy, the empirical results would suggest that incomplete markets are more likely to be prevalent. This implies that during the last fifteen years bank credit in Italy may have constrained the optimal pattern of firms' investments, with banks focusing merely on short-term productivity firm's performance and without accounting sufficiently for long-term investments.

Second, our results show that in most countries credit is more elastic to productivity for small rather than large firms. This means that for the same amount of credit provided, smaller firms would have a larger productivity outcome than the one experienced by larger ones. This is a relevant result because large firms represent a big share of employment and value added in an economy. Therefore, making sure that capital gets allocated to its most productive uses is particularly important across large firms.

In order to improve the overall allocation of credit and its impact on long-term growth, policy makers could explore the possibility to reconsider the role of productivity in the models of risk assessment that banks use to determine lending. Putting a higher weight on productivity and asking for productivity measures such as TFP would provide an incentive for banks to lend to more productive firms. This should be feasible especially for large firms that can provide all the information needed at a lower cost than small firms. This would improve the allocation of bank credit from a macroeconomic perspective and ensure a higher productivity growth for the economy.

References

[1] Amiti, M., and D.E. Weinstein, 2011. "Exports and Financial Shocks", *Quarterly Journal of Economics*, 126, 1841-1877.

[2] 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.

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

[4] Calligaris, S, Del Gatto, M., Hassan, F., Ottaviano, G.I.P., and F. Schivardi. 2016. "Italys 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] Chodorow-Reich, G., 2014. "The Employment Effects of Credit Market Disruptions: Firm- level Evidence from the 2008-9 Financial Crisis," *The Quarterly Journal of Economics* 129,159.

[8] 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.

[9] Guiso, L., Sapienza P., Zingales, L., 2004. "Does local financial development matter?," *Quarterly Journal of Economics*, 119, 929–969.

[10] 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.

[11] Hsieh, Chang-Tai, and Peter J. Klenow, 2009. Misallocation and manufacturing TFP in China and India. *Quarterly Journal of Economics*, 74, 1403-1448.

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

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

[14] Jimenez, G., Ongena, S., Peydro J.L., and J. Saurina, 2014. "Hazardous Times for Monetary Policy: What do 23 Million Loans Say About the Impact of Monetary Policy on Credit Risk-Taking?", *Econometrica*, 82 (2), 463-505.

[15] Khwaja, A. I., and A. Mian,2008. "Tracing the impact of bank liquidity shocks: Evidence from an emerging market", *American Economic Review*, 98, 1413?1442.

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

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

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

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

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

[20] Olley, G.S. and A. Pakes, 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 firm-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.

Appendix: estimation of firm-level TFP

The starting point of the estimation of firm-level TFP is a standard Cobb-Douglas production function:

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

where Y_{it} is real value added of firm i at time t, K is the real book value of net capital, L is total employment, and A is the object of interest TFP.

As it is well renown, estimating TFP using a standard Cobb-Douglas setting is subject to endogeneity problems between the input levels and the unobserved firm-specific productivity. Therefore, following the approach of Olley and Pakes (1996) and Levinshon and Petrin (2003) the unobserved firm-specific productivity is controlled for by a proxy of the unobserved productivity derived from a structural model. This proxy is a function of capital and material inputs that is approximated by a third-order polynomial, as in Petrin et al. (2004). Therefore, the following regression is then estimated on a 2-digit industry level using GMM, with the moments restrictions specified as in Woolridge (2009):

$$\mathrm{y}_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 k_{i(t-1)} + \beta_3 m_{i(t-1)} + \beta_4 k_{i(t-1)}^2 + \beta_5 m_{i(t-1)}^2 + \beta_6 k_{i(t-1)}^3 + \beta_7 m_{i(t-1)}^3 + \beta_8 k_{i(t-1)} m_{i(t-1)} + \beta_9 k_{i(t-1)} m_{i(t-1)}^2 + \beta_{10} k_{i(t-1)}^2 m_{i(t-1)} + \gamma Year_t + \omega l_{it}$$

All variables are in logs, y_{it} is the real value added of firm i at time t, k is the real book value of net capital, m is material inputs, and l is total employment. While capital takes time to build, labor and TFP are simultaneously determined, so labor is instrumented by its first lag.

TFP is then retrieved as $TFP_{it} = rva_{it} - (\hat{\beta}_0 + \hat{\beta}_1 k_{it} + \hat{\gamma} Year_t + \hat{\omega} l_{it})$.
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 imply that productivity shocks at time t do not depend from capital at time t, but on past productivity realizations and 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.

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

Table 2: Baseline results on loans

Elasticity of bank loans to:	**France**			**Germany**			**Italy**		
	t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP	-27%***	14.4%***	4.4%***	-8%***	6.1%***	1%	0.8%***	2.4%***	0.1%
MRPK	-51%***	7.6%***	2%***	-24%***	5.1%***	3.8%***	-0.3%***	0.1%***	-0.005%***
LProd	-17%***	10.3%***	3.5%***	-7%***	5.7%***	1%	4.4%***	3.4%***	0%
RVA	17%***	22.5%***	6.4%***	-0.1%	8.8%***	1.3%	12%***	1.2%	0%

***, **, * Significant at the 1%, 5% and 10% level. The elasticities at time $t+1$ and $t+2$ are computed separately. The regressors enter each specification independently and they are the marginal product of capital, total factor productivity, labor productivity, and real value added. All specifications include time and sector dummies.

Table 3: Baseline results by firm size

Elasticity of bank loans to:		France			Germany			Italy		
		t	t+1	t+2	t	t+1	t+2	t	t+1	t+2
TFP	Small	-29%***	18%***	3.7%***	-9%***	7.3%***	0.1%	1%***	2.5%***	0.1%
	Large	-22%***	9%***	5.6%***	-8%***	5.1%***	1.1%	-1.6%***	0.6%	-1%
MRPK	Small	-59%***	10%***	1.7%***	-24%***	4.6%***	3.9%***	-0.3%***	0.1%***	-0%***
	Large	-36%***	5%***	3.3%**	-24%***	5.2%***	3.8%***	-0.9%***	0.1%	-0.2%**
Lprod	Small	-16%***	14%***	2.32%**	-5%***	7%***	0.7%	4.6%***	0.4%	- 0.03%
	Large	-18%***	5%***	5.2%***	-7%***	5%***	1.2%	0.1%	4.6%**	-1.2%*
RVA	Small	15%***	26%***	5.7%***	-0.3%	10.3%***	2.7%**	13%***	1.3%	0%
	Large	22%***	18%***	7.4%***	0%	8%***	0.1%	5%***	0.3%	-0.1%

***, **, * Significant at the 1%, 5% and 10% level. The elasticities at time $t+1$ and $t+2$ are computed separately. The regressors enter each specification independently and they are the marginal product of capital, total factor productivity, labor productivity, and real value added. All specifications include time and sector dummies.

Figures

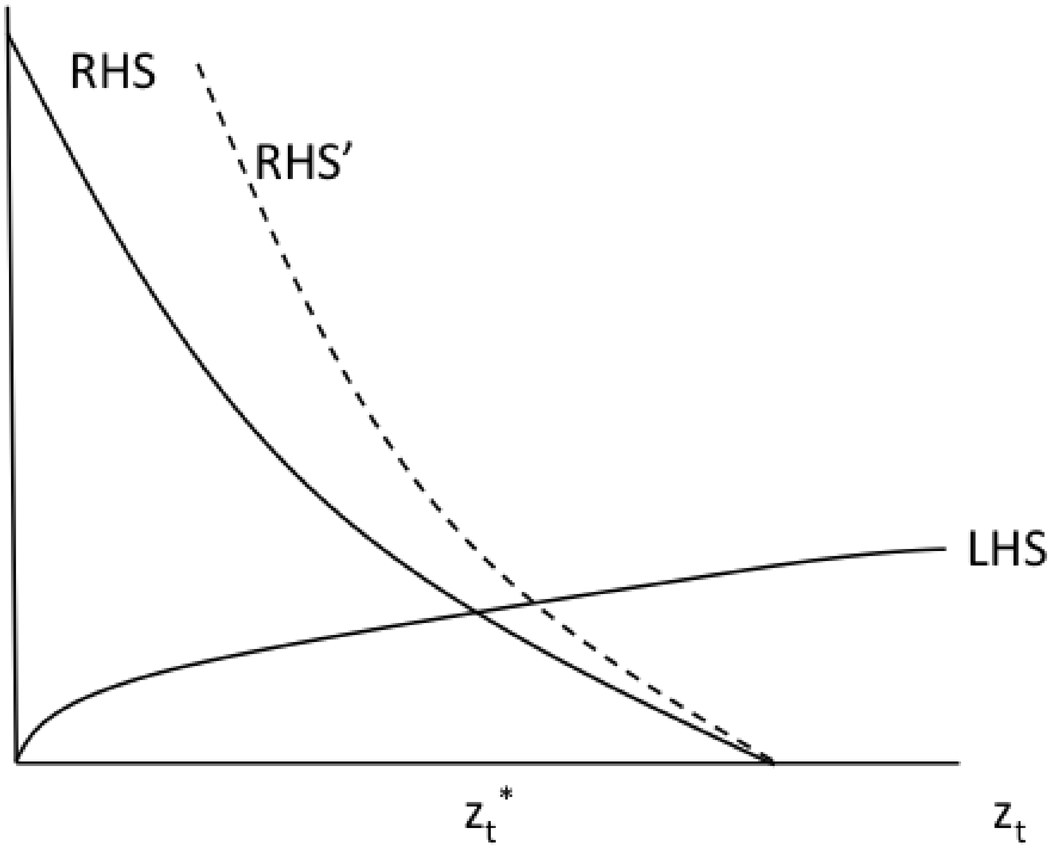

Figure 1: Productivity shock and borrowing under incomplete markets