
1. Financial development and innovation-led growth

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1 INTRODUCTION

For at least 5000 years, people have created, modified and used financial instruments, markets and intermediaries. Whether it was the use of money and debt to facilitate specialization and investment in Babylonia in 3000 BC (Van de Mieroop, 2005), the creation of market-traded securities in ancient Rome to mobilize capital for immense mining projects (Rostovtzeff, 1957; Malmendier, 2005), the regular issuance and trading of derivative contracts to manage risks and foster international trade in twelfth-century Europe (Swan, 2000), the development of investment banks to underwrite securities for railroads and other enterprises in the nineteenth century (Carosso, 1970), the formation and adaptation of venture capital firms to fuel high-tech innovations in the twentieth century (Kortum and Lerner, 2001), or the invention of new financial institutions to identify and fund promising biotechnologies in the twenty-first century (Gompers and Lerner, 2001; Schweitzer, 2006; Hall and Lerner, 2010), finance has been an integral feature of economic growth.

The pioneering work of Bagehot (1873), Schumpeter (1912), Gurley and Shaw (1955), and Goldsmith (1969) emphasized the inextricable connections between finance and economic growth. Ever since, much has been done to improve our understanding of the finance–growth nexus, both on theoretical and empirical grounds.

On the empirical side, a diverse body of research since the 1990s indicates that finance does not simply follow or accompany economic growth; it exerts a causal impact on growth. Historical case studies are consistent with the view that improvements in financial systems spur economic growth.¹ Cross-economy, industry-level, and finance-level studies demonstrate that (1) the positive finance–growth relationship holds when using several strategies to address identification concerns; (2) better-functioning finance systems ease the credit constraints that impede firm and industrial expansion, suggesting that this is one mechanism through which finance influences growth; and (3) finance fosters aggregate economic growth by improving the allocation of capital and accelerating the rate of technological innovation.² While not definitive, the preponderance of evidence suggests

¹ On historical case studies, see, for example, Sylla (1969), Haber (1991, 1995, 2010), Rousseau and Wachtel (1998), Davis and Gallman (2001), Guinnane (2002), Bodenhorn (2003; see also Chapter 4 in this volume), Haber, Maurer, and Razo (2003), Rousseau and Sylla (2005), Haber, North, and Weingast (2008), Temin and Voth (2013), Summerhill (2015; see also Chapter 8 in this volume), Voth (Chapter 6 in this volume).

² On identifying the overall impact of finance on growth, see, for instance, King and Levine (1993a), Townsend (1994, 1995), Jayaratne and Strahan (1996), Demirgüç-Kunt and Maksimovic (1998), Levine and Zervos (1998), Rajan and Zingales (1998), Levine, Loayza, and Beck (2000), and Guiso, Sapienza, and Zingales (2004a). On the mechanisms, the seminal work of Rajan and Zingales (1998) establishes that finance influences growth by influencing the severity of credit constraints. King and Levine (1993a), Levine and Zervos (1998), Beck, Levine, and Loayza (2000), and Jeong and Townsend (2007) emphasize that finance shapes growth by influencing productivity growth. On the connections between finance and innovation, see, for example,

that finance exerts a first-order impact on economic growth by shaping the severity of credit constraints and the rate of technological innovation. Levine (1997, 2005) and Popov (Chapter 3 in this volume) survey this empirical literature.

On the theory side, extensive research explores how the emergence of financial instruments, markets, and intermediaries can improve resource allocation, facilitate technological innovation, and spur economic growth. In particular, researchers show how financial systems can foster innovation-led growth by (1) reinvestments (e.g., Boyd and Prescott, 1986; Greenwood and Jovanovic, 1990; King and Levine, 1993b); (2) lowering the costs of monitoring projects and governing corporations (e.g., Townsend, 1979; Diamond, 1984; De La Fuente and Marín, 1996; Aghion, Dewatripont, and Rey, 1999; and Greenwood, Sanchez, and Wang, 2010); (3) facilitating the trading, hedging, and pooling of risk (e.g., Bencivenga and Smith, 1991; Levine, 1991; Acemoglu and Zilibotti, 1997; Allen and Gale, 1997; Aghion et al., 2010); (4) easing the accumulation of physical and human capital (e.g., Townsend and Ueda, 2006); and (5) lowering transactions costs and thereby promoting specialization (e.g., Bencivenga, Smith, and Starr, 1995; Greenwood and Smith, 1996; Galetovic, 1996). In all these models, financial contracts, markets, and intermediaries can accelerate growth by easing constraints on the flow of capital to its most efficient uses.

Researchers have also explored the implications of financial systems that ease credit constraints and accelerate growth on income inequality and macroeconomic volatility. On income inequality, theory suggests that easing credit constraints will increase the flow of credit – and hence economic opportunities – to those with the worthiest entrepreneurial ideas rather than to those with the most collateral. This not only implies a more efficient allocation of resources and faster economic growth, it also reduces income inequalities and expands the economic horizons of those with less wealth (e.g., Banerjee and Newman, 1993; Galor and Zeira, 1993; Aghion and Bolton, 1997; Piketty, 1997; Aghion, 2002; Townsend and Ueda, 2006). Indeed, empirical work finds that financial systems that ease credit constraints disproportionately boost the incomes of low-income individuals, putting downward pressures on income inequality (e.g., Beck, Demirgüç-Kunt, and Levine, 2007; Beck, Levine, and Levkov, 2010; Levine, Levkov, and Rubinstein, 2014).

On volatility, models of credit constraints and growth suggest that financial systems that ease credit constraints allow firms to borrow and make investments during recessions when the costs of investing are low but collateral values are also low. By facilitating the funding of efficient investments during recessions, better-developed financial systems not only boost growth, they also foster countercyclical investments that reduce the severity of business cycle fluctuations. Aghion et al. (2010), who develop this finance-growth-volatility model, also provide empirical evidence consistent with this prediction. Thus, empirical research suggests that financial development tends to improve aggregate growth, technological innovation, income equality, and macroeconomic stability.

In this chapter, we examine several implications of introducing credit constraints into the Schumpeterian growth paradigm developed by Aghion and Howitt (1992, 2006,

Benfratello, Schiantarelli, and Sembenelli (2008), Brown, Fazzari, and Petersen (2009), Brown, Martinsson, and Petersen (2012, 2013, 2017), Aghion, Van Reenen, and Zingales (2013), Amore, Schneider, and Zaldokas (2013), Chava et al. (2013), Fang, Tian, and Tice (2014), Hsu, Tian, and Xu (2014), Cornaggia et al. (2015), Laeven, Levine, and Michalopoulos (2015), Akcigit, Grigsby, and Nicholas (2017), and Levine, Lin, and Wei (2017).

2008). In this paradigm, growth reflects the decisions of profit-maximizing entrepreneurs, who determine how much to invest in the costly, risky – and potentially lucrative – process of innovation. That is, the primary determinants of long-run growth are the entrepreneurs' incentives and abilities to identify, fund, and commercialize quality-improving innovations. Since entrepreneurs may lack the wealth to self-finance their innovative ideas or may be reluctant to bear all the risks, there is a role for the financial system to help (1) entrepreneurs mobilize funds from savers; (2) savers identify, fund, and monitor entrepreneurs; and (3) savers and entrepreneurs to trade, hedge, and pool risks. We investigate how financial arrangements that ease credit constraints influence the decisions of entrepreneurs and thereby change technological innovation, economic growth, convergence among economies, the connections between macroeconomic volatility and growth, and income distribution.

There are both advantages and disadvantages to using any single theoretical paradigm to frame the theoretical literature on finance and growth. With respect to disadvantages, we emphasize two. First, we do not trace the connections starting from individual information and transactions costs, through to the emergence of specific financial instruments, markets, and intermediaries, and on to economic growth. Thus, we do not consider a large literature on the relationship between economic growth and the emergence of different mixtures of financial markets and intermediaries (e.g., Allen and Gale, 1997; Levine and Zervos, 1998; Levine, 2002, 2005; Beck and Levine, 2002; Brown, Martinsson, and Petersen, 2017; Allen, Gu, and Kowalewski, Chapter 2 in this volume). Rather, we note that extensive research demonstrates how an array of market frictions produce credit constraints and then examine the implications of these constraints on growth. A second disadvantage is that we do not compare and contrast different modeling strategies for examining the finance–growth nexus (e.g., Greenwood and Jovanovic, 1990; King and Levine, 1993; Galetovic, 1996; Acemoglu and Zilibotti, 1997; Townsend and Ueda, 2006; Greenwood et al., 2010).

The main advantage of our approach is that we examine the connections between finance and innovation-led growth within the context of a unified theoretical model. This allows us to investigate systematically how the easing of credit constraints shapes many macroeconomic phenomena, including technological innovation, the rate of economic growth within a country and in comparison to other countries, the connections between economic volatility and long-run growth, and the evolution of the distribution of income.

The remainder of the chapter is organized as follows. In Section 2, we introduce credit constraints and financial development into a simple version of the Schumpeterian growth model. In Section 3, we show how the interplay between credit constraints and innovation can help explain comparative growth across countries. In Section 4, we explore the connections between credit constraints and the business cycle and show that higher macroeconomic volatility is more detrimental to innovation-led growth when there are tighter credit constraints. Section 5 examines the relationship between credit constraints, wealth inequality, and growth. Theory advertises how better-developed financial systems can reduce the importance of inherited wealth, expand economic opportunities, and reduce inequality. Section 6 concludes.

2 INTRODUCING CREDIT CONSTRAINTS INTO THE BASIC SCHUMPETERIAN FRAMEWORK

In this section, we introduce credit constraints into the basic Schumpeterian model of economic growth. The quintessential feature of Schumpeterian growth models is that profit-maximizing entrepreneurs determine how much to invest in the costly and risky process of innovation, where a successful innovation gives the entrepreneur a monopoly on an improved production technology. The model is Schumpeterian in that successful innovations make existing technologies obsolete, and it is these successful innovations that drive economic growth – that is, the model captures Schumpeter’s (1912, 1942) focus on creative destruction. The model includes credit constraints in that entrepreneurs do not have the wealth (or inclination) to self-finance innovation. Thus, innovation requires that entrepreneurs raise funds in financial markets or from financial institutions. The various information and transactions costs that impede entrepreneurs from raising credit define the restrictiveness of credit constraints. Put differently, financial development in this model is the degree to which financial instruments, markets, and intermediaries ameliorate the information and transactions costs that impede the efficient flow of resources to promising endeavors. By easing credit constraints, therefore, financial development can foster innovation and growth. In this way, introducing credit constraints and a financial system into the basic Schumpeterian framework allows us to explore the relationship between finance and innovation-led growth.

2.1 A Toy Version of the Schumpeterian Growth Model

2.1.1 Basic setup

The economy has a fixed population L , which we normalize to unity. Everyone is endowed with one unit of labor services in the first period and none in the second, and are risk-neutral. There is one final good, produced under perfect competition by labor and a continuum of intermediate inputs according to:

$$Y_t = L^{1-\alpha} \int_0^1 A_{it}^{1-\alpha} x_{it}^\alpha di, \quad 0 < \alpha < 1 \quad (1.1)$$

where x_{it} is the input of the latest version of intermediate good i and A_{it} is the productivity parameter associated with it. The final good is used for consumption, as an input to R&D, and also as an input to the production of intermediate products. Everyone lives two periods, are endowed with one unit of labor services in the first period (when young) and zero units of labor services in the second period (when old), and are risk-neutral.

In this basic setup, we take several features of the contracting and competitive environment as given. For example, we do not explore how differences in competition, and hence the period over which an innovator can charge a monopoly price, influences innovation. This is explored in models by Aghion et al. (2001, 2005) and empirical evidence is provided by Aghion et al. (2009), Khandelwal (2010), Ayyagari, Demirgüç-Kunt, and Maksimovic (2011), and Amiti and Khandelwal (2013). Relatedly, we do not explore the efficacy of the intellectual property rights system that shapes the market power granted to innovators and the legal definition of what constitutes an innovation. Scholars have examined the

connections between intellectual property rights and innovation from many different perspectives (e.g., Sokoloff, 1988; Helpman, 1993; Aghion and Howitt, 2008). We simply take the property rights system as given and focus on the role of credit constraints and financial development in shaping innovation. Furthermore, we do not examine the industrial organization of innovative activity, which might be sole proprietorships, commercial firms and designated research enterprises. On the management and organization of innovation, see, for example, Sokoloff and Khan (1990), Aghion and Tirole (1994), Hart (1995), and Lamoreaux and Sokoloff (1999).

Let $A_{t-1} = \int_0^1 A_{i,t-1} di$. An entrepreneur in sector i that succeeds in innovating will have the productivity parameter $A_{it} = \gamma A_i$, where $\gamma > 1$ is the size of innovations, while the monopolist in a non-innovating sector will have $A_{it} = A_{i,t-1}$.

The innovation technology is as follows: to innovate with probability μ to achieve productivity level $A_i^* = \gamma A_{i,t-1}$, a firm needs to spend:

$$R_i = A_i^* \delta \mu^2 / 2 \tag{1.2}$$

units of final good in R&D. Note that for any given expenditures on innovation, R_i , the probability of successfully innovating is decreasing in the level of technology, A_i^* , and δ , which represents the inefficiency of turning expenditures on innovation into productivity-improving innovations. The equilibrium R&D intensity μ , and therefore the equilibrium growth rate (see below), will depend upon the equilibrium profit of an innovator, which we now calculate.

2.1.2 Equilibrium production and profits

In each intermediate sector where an innovation has just occurred, the monopolist is able to produce any amount of the intermediate good one for one with the final good as input. Her price will be the marginal product of her intermediate product:

$$p_{it}(x_{it}) = \alpha A_{it}^{1-\alpha} x_{it}^{\alpha-1}.$$

The equilibrium profit will then be equal to:

$$\Pi_{it} = \max_{x_{it}} \{p_{it}(x_{it})x_{it} - x_{it}\}.$$

From the first order conditions, we obtain:

$$x_{it} = \alpha^{\frac{2}{1-\alpha}} A_{it}.$$

Therefore,

$$p_{it}(x_{it}) = \frac{1}{\alpha}$$

so that the equilibrium profit is equal to:

$$\Pi_{it} = \pi A_{it},$$

where $\pi \equiv \left(\frac{1}{\alpha} - 1\right)\alpha^{\frac{2}{1-\alpha}}$. Consequently, gross output of the final good is:

$$Y_t = \alpha^{\frac{2\alpha}{1-\alpha}} A_t, \quad (1.3)$$

which is proportional to the average productivity parameter A_t , so the rate of economic growth will equal the productivity growth rate g .

2.1.3 Equilibrium innovation and growth without credit constraint

The entrepreneur will choose the research expenditure R_t so as to maximize her expected payoff. According to the above innovation production function, choosing R_t is equivalent to choosing the innovation probability μ . So, her profit-maximization problem is to choose the μ that maximizes:

$$\mu\pi A_t^* - A_t^*\delta\mu^2/2. \quad (1.4)$$

Thus, the equilibrium probability of innovation is:

$$\mu = \pi/\delta, \quad (1.5)$$

which is constant over time and the same for all sectors.

Then, by the law of large numbers, a fraction μ of sectors (those who have innovated) will have productivity γA_{t-1} while the remaining fraction $(1-\mu)$ will have A_{t-1} . The average across all sectors will therefore be:

$$A_t = \mu\gamma A_{t-1} + (1-\mu)A_{t-1},$$

implying that the growth rate of average productivity is:

$$g = \frac{A_t - A_{t-1}}{A_{t-1}} = \mu(\gamma - 1). \quad (1.6)$$

From this and (1.5), the equilibrium growth rate is:

$$g = (\pi/\delta)(\gamma - 1). \quad (1.7)$$

Growth is positively related to the profitability of innovation (π), the efficiency with which expenditures on innovation translate into successful productivity enhancements ($1/\delta$), and the incremental increase in productivity from a successful innovation (γ).

2.2 Introducing Credit Constraints

Each innovator at date t is a young person with access to the wage income ω_{t-1} , who must borrow $L = R_t - \omega_{t-1}$. Suppose the borrower might default. By paying a cost hR_t , where $0 < h < 1$, the entrepreneur can hide the result of a successful innovation and thereby avoid repaying. The cost parameter h is an indicator of the bank's effectiveness in monitoring, so that a well-functioning bank makes it very expensive for entrepreneurs to engage in

fraud. The cost also reflects the effectiveness of legal institutions in protecting creditors' rights; in a country where courts rarely enforce loan contracts, it is relatively inexpensive for entrepreneurs to default on their debts.

Thus, we focus on the role of the financial system in monitoring whether borrowers accurately report the success of their endeavors. Our focus on monitoring relates to the fundamental work of Townsend (1979) on costly state verification, which has been used to examine the linkages between finance and growth (e.g., Bencivenga and Smith, 1991; De La Fuente and Marín, 1996; Aghion, Dewatripont, and Rey, 1999; Greenwood et al., 2010). Other researchers exploring the finance–growth nexus have focused on different services provided by the financial system to the economy, such as screening potential innovators (e.g., Greenwood and Jovanovic, 1990; King and Levine, 1993b; Laeven et al., 2015), easing risk management (e.g., Levine, 1991; Allen and Gale, 1997; Acemoglu and Zilibotti, 1997), and facilitating specialization (e.g., Greenwood and Smith, 1996). The entrepreneur must pay the hiding (hR_t) cost at the beginning of the period, when she decides whether or not to be dishonest. She will do so when it is in her self-interest, namely when the following incentive-compatibility constraint is violated:

$$hR_t \geq \mu_t(R_t)\Gamma(R_t - \omega_{t-1}), \tag{1.8}$$

where Γ is the interest factor on the loan and $\mu_t(R_t)$ is the probability of innovating at date t given the R&D investment R_t . The right-hand side (RHS) of (1.8) is the expected saving from deciding to be dishonest; that is, by being dishonest you can avoid making the repayment, which is the interest factor Γ times the loan amount, in the event the project succeeds, which happens with probability μ .

The only potential lenders in this overlapping generation model are other young people, who will lend only if the expected repayment equals the loan amount. Thus, even though there is no time cost to the project, there will be a positive interest factor on the loan, given by the arbitrage condition:

$$\mu_t(R_t)\Gamma = 1,$$

which states that for every dollar lent out, the expected repayment (Γ with probability μ) must equal one. Using this arbitrage condition to substitute for Γ we see that the incentive-compatibility condition (1.8) boils down to an upper limit on the entrepreneur's investment:

$$R_t \leq \frac{1}{1-h}\omega_{t-1} = v\omega_{t-1} = \hat{R}_t \tag{1.9}$$

The parameter v is positively related to financial development and is commonly referred to as the *credit multiplier*. A higher cost h of hiding innovation revenue implies a larger credit multiplier.

2.2.1 Innovation and growth under binding credit constraint

The constraint (1.9) will be binding if \hat{R}_t is less than the R&D cost of achieving the innovation probability (1.5) that would be undertaken in the absence of financial constraints, given the above R&D cost function:

$$v\omega_{t-1} < \gamma A_{t-1} \pi^2 / (2\delta). \quad (1.10)$$

The equilibrium wage ω_{t-1} is the marginal product of labor, which under the Cobb-Douglas specification in (1.1) equals $(1 - \alpha)$ times final output Y_{t-1} ; this, together with (1.3) implies:

$$\omega_{t-1} = \omega A_{t-1},$$

where $\omega = (1 - \alpha)\alpha^{\frac{2\alpha}{1-\alpha}}$.

Thus, we can rewrite the condition (1.10) as:

$$v < \gamma \pi^2 / (2\delta\omega). \quad (1.11)$$

It follows that entrepreneurs are less likely to face a credit constraint when either financial development is higher, as measured by v , or entrepreneurs' initial wealth ω as a fraction of aggregate output is higher. This is because a large v implies a large cost of defrauding a creditor, which makes creditors willing to lend more, and a large ω gives entrepreneurs more wealth, which makes them better able to self-finance when creditors are unwilling.

Whenever (1.11) holds, the equilibrium growth rate is obtained by substituting the constrained investment at: $\hat{R}_t = v\omega_{t-1}$ into the above innovation production function to arrive at:

$$g^h = (\gamma - 1)\sqrt{2v\omega/\delta\gamma},$$

which is monotonically increasing in financial development as measured by v and in entrepreneur's wealth as measured by ω . Note that g^h does not depend on productivity-adjusted profit π . This is because although a higher profit rate would make entrepreneurs want to do more research, it does not affect the incentive compatibility constraint, and hence does not make lenders willing to finance any more research. Thus, it is only when the credit constraint is not binding that higher profitability translates into faster growth.

When (1.11) does not hold, then the growth rate is the same as it was in the absence of credit constraints, namely:

$$g = \mu^*(\gamma - 1) = (\pi/\delta)(\gamma - 1).$$

In this case, profitability again matters but financial development and the wealth of entrepreneurs no longer matters.

2.3 Empirical Evidence

Substantial research provides empirical evidence on key predictions from this Schumpeterian growth model with credit constraints. First, the model predicts that better-developed financial systems – financial systems that make it more expensive for entrepreneurs to defraud creditors (i.e., financial systems with large v) – ease credit constraints and thereby spur technological innovation and the rate of economic growth. Thus, we discuss research on the relationship between financial development and the rates of economic

growth and technological innovation.³ Second, researchers also examine the determinants of the effectiveness with which financial systems make it more expensive for entrepreneurs to defraud creditors and thereby ease credit constraints. Thus, we briefly discuss research on the legal, regulatory, and cultural determinants of financial development.

Research on the impact of financial development on innovation and growth differs along several dimensions. With respect to the unit of analyses, researchers use cross-country, cross-region, cross-industry, cross-firm, and time-series analyses to assess the relationship between financial development and economic growth. With respect to the dependent variable, most researchers examine the growth rate in output per person, though some examine proxies for the rate of technological innovation, such as total factor productivity growth, investment in research and development, or the growth rate in patents. With respect to the measurement of financial development, researchers use aggregate measures such as the ratio of bank credit to gross domestic product (GDP) or the ratio of stock market liquidity to GDP, while others focus on policy innovations that altered the quality of financial services.

To provide a bit more structure to this discussion, consider the following simple cross-country (or panel) regression:

$$g_i = \beta_0 + \beta_1 \text{findev}_i + \beta_2 X_i + u_i,$$

where g_i is the average growth rate in country i during the period or subperiod, findev_i is the country's level of financial development (either at the beginning of the period, or averaged over the period), X_i is a vector of controls (policy variables, education, political stability, initial income per capita, etc.) and u_i is an error term.

Based on this equation, King and Levine (1993a) consider a sample of 77 countries over the period 1960 to 1989. They regress the average growth rate of per capita GDP or average growth rate of total factor productivity on financial development and an array of control variables. To measure financial development, they use the ratio of credit to GDP and similar aggregate indicators. They discover a large, positive, and statistically significant correlation between financial development and both economic and productivity growth. They push things a bit farther by repeating the same regression exercise but using initial values of financial development in 1960 instead of the average level of financial development over the 1960–89 period. The results hold, indicating that financial development in 1960 is a good predictor of economic and productivity growth over the next 30 years. Levine and Zervos (1998) push things still farther by including stock markets. They examine the relationship between both banking system development and stock market development and GDP growth and productivity growth. For banking system development, they again use measures of bank credit to GDP. To measure stock market development, they use measures of stock market liquidity such as the ratio of the total value of traded shares to the total value of listed shares. Based on cross-country regressions involving 42 countries over the period 1976–93, they discover that both banks

³ Moving beyond the specific confines of our model, the Schumpeterian growth model allows for other features of an economy's financial system to shape credit constraints, such as screening entrepreneurs, diversifying risk, and facilitating transactions. As stressed by Levine (1997, 2005), these functions of the financial system may also shape the rates of technological innovation and aggregate economic growth.

and stock markets matter. The initial level of bank credit *and* the initial level of stock market liquidity in 1976 are each positively and significantly correlated with GDP and productivity growth over the 1976–93 period.

These findings both advertised the connections between finance and development and raised concerns about identification that sparked much additional research. For example, Beck et al. (2000), Levine et al. (2000), and Beck and Levine (2004) use panel techniques to address endogeneity concerns and confirm the original findings. Other researchers use instrumental variables to identify the exogenous component of financial development. For example, Levine (1998, 1999) and Levine et al. (2000) use the legal origins indicators from La Porta et al. (1998) as instruments for financial development. This work also confirms a strong, positive, and statistically significant relationship between financial development and both productivity and aggregate growth. To address identification and measurement concerns, others shift to cross-regional analyses, such as looking across the states of the USA (e.g., Jayaratne and Strahan, 1996) or looking across the regions of Italy (e.g., Guiso, Sapienza, and Zingales, 2004a). These findings also confirm the original King and Levine (1993a) and Levine and Zervos (1998) findings: improvements in the functioning of financial systems spur economic growth by improving the allocation of credit. In a pioneering study, Rajan and Zingales (1998) use cross-country, cross-industry comparisons to evaluate the impact of finance on growth. Their insight is that growth in industries that rely more heavily on external finance should benefit more from financial development than growth in industries that rely less heavily on external finance. Using a sample of 36 industries in 42 countries, Rajan and Zingales confirm this conjecture: greater financial development enhances growth in those industries that rely more heavily on external finance.

Empirical research has also focused on the connections between finance and innovation. Using an array of econometric strategies, a large and growing literature estimates the impact of finance on innovation. The findings from this literature are also consistent with the view that credit constraints impede investment in innovative activities and that greater financial development eases these constraints and allows more resources to flow toward promising entrepreneurs, accelerating technological innovation and economic growth. See, for example, Brown et al. (2009, 2012, 2013, 2017), Aghion, Van Reenen, and Zingales (2013), Amore et al. (2013), Chava et al. (2013), Fang et al. (2014), Hsu et al. (2014), Cornaggia et al. (2015), Laeven et al. (2015), Madsen and Ang (2016), Akcigit et al. (2017), and Levine et al. (2017).

Researchers also examine the legal, regulatory, institutional, and cultural factors that shape financial development. Within the model above, this means the factors that shape “ v ” – the costs to entrepreneurs to defraud creditors. More generally, this means the factors that shape how well financial systems screen entrepreneurs, monitor entrepreneurs, manage risk, pool resources, and facilitate transactions.

La Porta et al. (1997, 1998) triggered an influential line of empirical research by showing that as European countries colonized much of the world, they spread distinct legal systems that have had enduring effects on the operation of finance systems. The subsequent “law and finance” literature has explored how legal system differences shape financial development (e.g., Claessens, Djankov, and Lang, 2000; La Porta et al., 2000; Beck, Demirgüç-Kunt, and Levine, 2003a, 2003b; Leuz, Nanda, and Wysocki, 2003; Beck, Demirgüç-Kunt, and Maksimovic, 2005; Djankov et al., 2008; Brown, Cookson, and Heimer, 2017).

Other researchers have explored different determinants of financial development. For instance, Barth, Caprio, and Levine (2004, 2008, 2012) explore – and provide literature reviews of research on – how financial regulation and supervisory practices shape the operation of banks. Stulz and Williamson (2003) argue that religions differ in their attitudes toward charging interest on loans and personal wealth accumulation, which shapes financial development. Guiso, Sapienza, and Zingales (2004b, 2008) note that social trust is crucial for financial market transactions because they involve unfamiliar counterparts and occur over time. Consistent with this view, research shows that interfirm trust shapes trade credit between firms (McMillan and Woodruff, 1999), Italian provinces with higher levels of social trust have greater financial development (Guiso et al., 2004b), Dutch individuals with greater social trust participate more in the stock market (Guiso et al., 2008), and trust facilitates borrowing in Peru (Karlan et al., 2009). Research also emphasizes the role of institutions that facilitate the flow of credit information about firms. Djankov, McLiesh, and Shleifer (2007) find that credit registries that effectively provide information on borrowers improve financial development.

While this discussion is not comprehensive, it makes two essential points. First, an extensive body of research provides evidence that is consistent with a core prediction of the Schumpeterian growth model with credit constraints: better-functioning financial systems ease credit constraints, foster a more efficient allocation of resources, spur technological innovation, and accelerate economic growth. Second, researchers are exploring the particular legal, policy, cultural, and institutional factors that shape financial development. We now turn from models of the linkages between finance and growth in a single economy framework to a world with multiple economies.

3 FINANCIAL DEVELOPMENT AND CLUB CONVERGENCE⁴

In this section we argue that financial development is a key driver of less developed countries' ability to converge towards the growth rates and/or per capita GDP levels of advanced countries. Convergence is driven by what we refer to as the "advantage of backwardness": namely, less developed economies can potentially benefit from knowledge spillovers from more countries closer to the technological frontier. In particular, the further behind a country is from the technological frontier, the bigger will be the increase in productivity each time a sector in that country catches up with the global technology leader. However, there may also be a "disadvantage of backwardness", whereby it is harder for a more backward country or sector to catch up with the frontier. One reason for the disadvantage of backwardness relates to finance: namely, firms in a credit-constrained country cannot invest more than a multiple of their current cashflows, which in turn are proportional to the country's current productivity (or technological level). On the other hand, the R&D cost of catching up with the frontier technology typically depends upon the frontier technology level. The larger the discrepancy between the country's productivity level and the frontier productivity, the more binding are the credit constraints on firms in the country. Technologically backward countries might not have sufficiently developed

⁴ This section is drawn from Aghion, Howitt, and Mayer-Foulkes (2005) and Aghion and Howitt (2008).

financial systems to fund effective investments in innovation. In this section, we explore the interplay between the advantage and disadvantage of backwardness and show that this gives rise to a rich set of convergence and divergence patterns.

3.1 A Simple Model of Schumpeterian Convergence

The model is identical to the one developed in the previous section, except that innovation involves technological spillovers from more advanced countries. More specifically, we assume the following innovation technology which captures the existence of knowledge spillovers:

$$A_{it} = \left\{ \begin{array}{ll} \bar{A}_t & \text{with probability } \mu_{it} \\ A_{i,t-1} & \text{with probability } 1 - \mu_{it} \end{array} \right\}$$

where \bar{A}_t is what we call the *world technology frontier*.

To catch up with the world technology frontier \bar{A}_t with probability μ , the incumbent firm in sector i needs to spend $c(\mu)\bar{A}_t$ units of the final good on R&D, where we assume that:

$$c(\mu) = \eta\mu + \delta\mu^2/2,$$

with $\eta > 0$ and $\delta > 0$.

The technological frontier \bar{A}_t corresponds to an idealized economy in which productivity in all intermediate sectors would always lie at the maximum level, so that:

$$\bar{A}_t = \max\{A_{it}\}.$$

For simplicity, we take growth of the frontier productivity to be exogenous and constant at rate g , thus:

$$\bar{A}_t = (1 + g)A_{t-1}.$$

The fact that a successful innovator gets to implement \bar{A}_t is a manifestation of technology transfer: that is, domestic R&D makes use of ideas developed elsewhere in the world.

Assume now that a competitive fringe can always produce an intermediate good embodying the previous technology. Then the unsuccessful innovator will earn zero profits and a successful innovator will earn π_{it} .

We can now characterize productivity dynamics as a function of the probability of innovation. Let $A_t = \int_0^1 A_{it} di$ be the average productivity parameter across all intermediate sectors. In equilibrium the probability of innovation will be the same in all intermediate sectors and constant over time: $\mu_{it} = \mu^*$ for all i ; therefore, average productivity will evolve according to:

$$A_t = \mu^* \bar{A}_t + (1 - \mu^*)A_{t-1}. \quad (1.12)$$

3.2 Distance to Frontier and Convergence Without Credit Constraints

3.2.1 The convergence equation

We now introduce the notion of *distance to frontier* (or *proximity to frontier*). Proximity to frontier is defined in each sector i by the ratio of the sector’s productivity to the frontier productivity, namely:

$$a_{it} = A_{it}/\bar{A}_t$$

Then the domestic economy’s average proximity to the frontier is simply determined by:

$$a_t = \int_0^1 a_{it} di = A_t/\bar{A}_t,$$

which is inversely related to the country’s distance to the technological frontier, or its “technology gap”.

Using the proximity to frontier variable, we can re-express the productivity dynamics equation as a very simple difference equation:

$$a_t = \mu^* + \frac{(1-\mu^*)}{1+g} a_{t-1}. \tag{1.13}$$

This converges in the long run to the steady-state value:⁵

$$a^* = \frac{(1+g)\mu^*}{g+\mu^*}. \tag{1.14}$$

To close the model, we just need to derive the equilibrium innovation probability μ^* .

3.2.2 Equilibrium innovation

Using the fact that the equilibrium profit of an innovating firm is equal to $\pi\bar{A}_t$, the equilibrium innovation rate μ^* will be the value of μ that maximizes the expected net payoff:

$$\mu\pi\bar{A}_t - c(\mu)\bar{A}_t, \tag{1.15}$$

where $c(\mu) = \eta\mu + \delta\mu^2/2$.

There are two cases to consider. Suppose first that:

$$\pi > \eta. \tag{1.16}$$

Then the reward to an innovation is large enough relative to the cost that producers will innovate at a positive rate. That is, the first-order condition for maximizing (1.15) is:

$$c'(\mu) = \delta,$$

whose solution is:

⁵ The steady-state value a^* is simply defined by the fixed-point condition: $a^* = \mu^* + \frac{(1-\mu^*)}{1+g} a^*$.

$$\mu^* = (\pi - \eta)/\delta > 0.$$

Second, suppose that:

$$\pi \leq \eta.$$

Then the conditions are so unfavorable to innovation in this country that producers will not innovate. That is, the first-order condition for maximizing (1.15) has no positive solution, so the maximization problem is solved by setting $\mu^* = 0$.

3.2.3 A crude form of club convergence

The above analysis yields the following two results:

Result 1: All countries with $\pi > \eta$ will grow at the same rate in the long run That is, all countries that innovate at a positive rate will converge to the same growth rate. The intuition underlying this convergence result can be formulated as follows: because of technology transfer, the further behind the frontier a country is initially, the bigger the average size of its innovations, and therefore the higher its growth rate for a given frequency of innovations. As long as the country continues to innovate at some positive rate, no matter how small, it will eventually grow at the same rate as the leading countries.

Formally, in this case $\mu^* > 0$, which implies that the country's steady-state proximity to the frontier (1.14) will be strictly positive and equal to a^* . This, in turn, means that for large enough t :

$$A_t \simeq a^* \bar{A}_t \tag{1.17}$$

since $a_t = A_t/\bar{A}_t$ converges to a^* . But (1.17) in turn implies that, in the long run, the numerator A_t must grow at the same rate as the denominator \bar{A}_t . That is, the country's productivity A_t will grow at the same rate g as the world productivity frontier.

Result 2: All countries with $\pi \leq \eta$ will stagnate in the long run That is, countries with a poor legal environment or education system will not innovate in equilibrium and therefore they will not benefit from technology transfer, but will instead stagnate. Formally, for these countries the fact that $\mu^* = 0$ means that their equilibrium proximity to the frontier a^* is zero, which means that their distance to the frontier, which is a_t^{-1} , is rising to infinity.

The resultant club convergence is somewhat too crude: either countries converge towards the growth rate of frontier countries, or they stagnate. But in reality, we observe that some countries do not converge to frontier growth even though they keep growing at a positive rate. As we shall see below, introducing credit constraints enriches the analysis and helps account for this fact.

3.3 Credit Constraints as a Source of Divergence

This section explores credit constraints as a source of cross-country divergence, based on Aghion, Howitt, and Mayer-Foulkes (2005), henceforth AHM. In a nutshell, we assume a two-period overlapping-generations structure in which the accumulated net

wealth of an entrepreneur is her current wage income ω_t , and in which there is just one entrepreneur per sector in each country. This means that the further behind the frontier the country falls the less will any entrepreneur be able to invest in R&D relative to what is needed to maintain any given frequency of innovation. What happens in the long run to the country's growth rate depends upon the interaction between this disadvantage of backwardness, which reduces the frequency of innovations, and the above-described advantage of backwardness, which increases the size of innovations. The lower the cost of defrauding a creditor, that is, the lower the credit multiplier v , the more likely it is that the disadvantage of backwardness will be the dominant force, preventing the country from converging to the frontier growth rate even in the long run. Generally speaking, the greater the degree of financial development of a country the more effective are the institutions and laws that make it difficult to defraud a creditor. This means financial development boosts the likelihood that a country converges to the frontier growth rate.

3.3.1 The convergence model with credit constraints

Suppose credit constraints prevent an entrepreneur with initial wealth ω_t from investing more than a multiple of her wealth $v\omega_t$ in innovation, as developed by Aghion, Banerjee, and Piketty (1999). This in turn allows her to innovate at most with probability μ , where:

$$c(\mu_{t+1})\bar{A}_{t+1} = v\omega_t \tag{1.18}$$

Using the fact that ω_t is proportional to A_t ,

$$\omega_t = \theta A_t,$$

and then dividing (1.18) by \bar{A}_{t+1} and using the fact that \bar{A}_t grows at rate g , we can re-express (1.18) in terms of the proximity to the frontier variable, namely:

$$c(\mu_{t+1}) = \kappa a_t, \tag{1.19}$$

where $\kappa = \frac{v\theta}{1+g}$. This equation determines μ_{t+1} as an increasing function of the proximity to frontier a_t . For example, if we assume the same R&D technology as in the previous section, so that:

$$c(\mu_t) = \eta\mu_t + \delta\mu_t^2/2,$$

then μ_{t+1} is given by:

$$\mu_{t+1} = \tilde{\mu}(\kappa a_t) = \frac{\sqrt{\eta^2 + 2\delta\kappa a_t} - \eta}{\delta},$$

which is increasing in a_t and equal to zero for $\omega = 0$ or $a_t = 0$.

The credit constraint will be binding on R&D investment if $\tilde{\mu}(\kappa a_t)$ is less than the optimal μ^* in the absence of credit constraints (here, we are implicitly assuming that $\mu^* = (\pi - \eta)/\delta > 0$). In this binding case, the convergence equation becomes:

$$a_{t+1} = \tilde{\mu}(\kappa a_t) + \frac{(1 - \tilde{\mu}(\kappa a_t))}{1 + g} a_t \equiv F_2(a_t)$$

which is non-linear in a_t . In particular, a country with very low a_t , that is, a country that is far below the world technology frontier, will converge at a lower rate than a country with higher a_t . And if ω is sufficiently small, a credit-constrained country will in fact diverge from the frontier because in that case:

$$a_{t+1} < a_t.$$

3.4 Evidence

AHM test this effect of financial development on convergence by running the following cross-country growth regression:

$$g_i - g_1 = \beta_0 + \beta_f F_i + \beta_y \cdot (y_i - y_1) + \beta_{fy} \cdot F_i \cdot (y_i - y_1) + \beta_x X_i + \varepsilon_i \quad (1.20)$$

where g_i denotes the average growth rate of per-capita GDP in country i over the period 1960–95, F_i the country's average level of financial development, y_i the initial (1960) log of per-capita GDP, X_i a set of other regressors and ε_i a disturbance term with mean zero. Country 1 is the technology leader, which they take to be the USA.

Define $\hat{y}_i \equiv y_i - y_1$, country i 's initial relative per-capita GDP. Under the assumption that $\beta_y + \beta_{fy} F_i \neq 0$, we can rewrite (1.20) as:

$$g_i - g_1 = \lambda_i \cdot (\hat{y}_i - \hat{y}_i^*)$$

where the steady-state value \hat{y}_i^* is defined by setting the RHS of (1.20) to zero:

$$\hat{y}_i^* = \frac{\beta_0 + \beta_f F_i + \beta_x X_i + \varepsilon_i}{\beta_y + \beta_{fy} F_i} \quad (1.21)$$

and λ_i is a country-specific convergence parameter:

$$\lambda_i = \beta_y + \beta_{fy} F_i \quad (1.22)$$

that depends on financial development.

A country can converge to the frontier growth rate if and only if the growth rate of its relative per-capita GDP depends negatively on the initial value \hat{y}_i ; that is, if and only if the convergence parameter λ_i is negative. Thus, the likelihood of convergence will increase with financial development, as implied by the above theory, if and only if:

$$\beta_{fy} < 0. \quad (1.23)$$

AHM conduct these analyses using a sample of 71 countries and find that the interaction coefficient β_{fy} is indeed significantly negative for a variety of different measures

of financial development and a variety of different conditioning sets X . The data, estimation methods and choice of conditioning sets X are all taken directly from Levine et al. (2000), who found a strongly positive and robust effect of financial intermediation on short-run growth in a regression identical to (1.20) but they did not consider the interaction term $F_i(y_i - y_1)$ that allows convergence to depend upon the level of financial development.⁶

4 CREDIT CONSTRAINTS, MACROECONOMIC VOLATILITY, AND GROWTH

Thus far, we have explored how improvements in the financial systems—the relaxation of credit constraints—influence the rate of technological innovation and aggregate economic growth in a single economy and across a set of economies. We now broaden our analyses and examine how financial systems simultaneously shape innovation, growth, and the volatility of the aggregate economy. This extension is motivated both by the strong, negative correlation between the volatility of output and the growth rate of output (Ramey and Ramey 1995) and the finding that better developed financial systems spur growth-enhancing investments in recessions and dampen economic volatility (AABM 2010).

In this section, we extend the model developed in Section 2 and show that credit-constraints impact firm investment decisions in ways that shape both growth and volatility. In particular, easing credit constraints facilitates growth-promoting investments and it facilitates those investments when they are least expensive: during recessions. This countercyclical investment reduces the severity of business cycles. Thus, the model predicts that the relationship between growth and volatility will be less negative for economies with well-developed financial systems and more negative for economies with under-developed financial systems.

A natural implication of this model is that financial development influences the efficacy of stabilization policies. In particular, countercyclical fiscal and monetary policies and macroeconomic policies will be more growth-enhancing in countries and sectors that are more financially constrained because they dampen the adverse effects of recession on growth-promoting investments.

4.1 The Argument

The theoretical argument in Aghion, Angeletos, Banerjee and Manova (2010), henceforth AABM, can be summarized as follows. In the absence of credit constraints, long-run

⁶ Laeven, Levine, and Michalopoulos (LLM) (2015) extend the model by AHM to allow for endogenous financial innovation. In particular, financial entrepreneurs can invest in a costly, risky innovation activity that, when successful, yields an improved ability to screen potential borrowers. This model focuses attention on improvements in the financial system, rather than on the level of financial development. It predicts that in the long run, cross-country differences in the rates of technological innovation and economic growth will be accounted for by differences in the rates of financial innovation, not differences in the initial levels of financial development. The LLM model augments the AHM growth equation used in their empirical study by adding an interaction term that captures financial innovation. They provide empirical evidence consistent with their prediction.

growth-enhancing investments tend to be countercyclical, as they often take place at the expense of directly productive activities. Because the return to the latter is lower in recessions due to lower demand for the manufactured good, so will the opportunity cost of long-run productivity-enhancing investments. Hence the possibility of a growth-enhancing effect of recessions.

However, things become quite different when credit market imperfections prevent firms from innovating and reorganizing in recessions: in a recession, current earnings are reduced, and therefore so is the firms' ability to borrow in order to innovate. This in turn implies that the lower financial development, the more the anticipation of recessions will discourage R&D investments if those are decided before firms know the realization of the aggregate shock (since firms anticipate that with higher probability, their R&D investment will not pay out in the long run as it will not survive the liquidity shock). Then recessions will have a damaging effect on R&D and growth. A natural implication of this argument is that macroeconomic policies that stabilize the business cycle should be more growth-enhancing in countries and sectors that are more financially constrained.

4.2 Evidence

That credit constraints affect the relationship between aggregate volatility and growth comes out very clearly in the following regression exercise, done by AABM. Annual growth is computed as the log difference of per capita income obtained from the Penn World Tables mark 6.1 (PWT). As in Ramey and Ramey (1995), aggregate volatility is, measured by taking the country-specific standard deviation of annual growth over the 1960–95 period. Financial development is measured by the ratio of private credit, that is the value of loans by financial intermediaries to the private sector, over GDP. Data for 71 countries on five-year interval averages between 1960 and 1995 (1960–64, 1965–69, etc.) was first compiled by Levine, Loayza, and Beck (2000); an annual dataset was more recently prepared and made available by Levine on his webpage.⁷

Then, building upon Ramey and Ramey, who studied the response of long-term growth to volatility, and upon Levine, Loayza, and Beck (2000), who focused on the direct effects of credit constraints on growth, AABM estimate the basic equation:

$$g_i = \alpha_0 + \alpha_1 \cdot y_i + \alpha_2 \cdot vol_i + \alpha_3 \cdot priv_i + \alpha_4 \cdot vol_i * priv_i + \beta \cdot X_i + \varepsilon_i,$$

where y_i is the initial income in country i , g_i denotes the average rate of productivity growth in country i over the whole period 1960–95, vol_i is the measure of aggregate volatility, $priv_i$ is the average measure of financial development over the period 1960–95, X_i is a vector of country-specific controls, and ε_i is the noise term.

Of particular interest is the interaction term $\alpha_4 \cdot vol_i * priv_i$, and here the prediction is

⁷ Private credit is the preferred measure of financial development by Levine, Loayza, and Beck (2000) because it excludes credit granted to the public sector and funds coming from central or development banks. AABM also conduct sensitivity analysis with two alternative measures of credit constraints, liquid liabilities and bank assets.

that α_4 should be positive and significant, whereas α_2 should be negative and significant, so that volatility is negatively correlated with growth in countries with low financial development, but less so when financial development increases.

AABM find a strong direct negative correlation between volatility and long-term growth and a significantly positive coefficient on the interaction term between volatility and financial development. For sufficiently high levels of private credit (which we observe for many OECD countries), these results predict that the overall contribution of volatility to economic growth becomes positive. Moreover, for intermediate levels of private credit the gross contribution may be close to zero. Regressing long-run growth on volatility alone without accounting for the direct and interacted effects of financial development could thus produce an insignificant coefficient. This may explain why Ramey and Ramey find a strong negative effect of volatility on growth in the full cross-section but a non-significant one in the OECD sample.

Finally, AABM show that the growth impact of both volatility itself and its interaction with private credit are little affected by the inclusion of investment as a control. However, controlling for the ratio of investment to GDP reduces the coefficient on volatility by only 20 percent, suggesting that 80 percent of the total effect of volatility on growth may be through a channel other than the rate of investment, having more to do with the composition of investment between short-term capital and long-term innovative investment.

A subsequent study by Aghion, Askenazy, Berman, Cette, and Eymard (2012) uses a French firm-level panel dataset covering 13000 firms over the period 1980–2000 to test the predictions of AABM. Credit constraints are measured at firm level by a firm's ability to obtain new bank loans, which turn out to depend upon the firm's credit record vis-a-vis its trade creditors. More specifically, firms that fail to repay their trade creditors are put on a black list called "Payment Incident", and being included on that list affects firms' ability to access credit in the future. Using the interaction between this firm-level instrument and a variable that reflects the dependence of the firm's industry upon external finance, and controlling for firm size, the paper shows: (1) that R&D spending is more positively correlated with sales in more credit-constrained firms; (2) that higher volatility of sales has an asymmetric effect on R&D investments: these are more harmed in slumps than they are encouraged in booms; (3) higher volatility is more harmful to productivity growth in more credit-constrained firms.

That R&D should be more pro-cyclical in more credit-constrained sectors and firms, in turn has implications for the conduct of macroeconomic policy and its effects on innovation and growth. In particular Aghion, Hemous and Kharroubi (2014), henceforth AHK, look at the growth effects of countercyclical fiscal policies. More precisely, AHK use cross-OECD cross-sector data to look at the effects of fiscal countercyclicity on sectoral productivity growth. Fiscal countercyclicity is measured by the extent to which a country increases its public deficit when the output gap increases. Their main finding is that in any non-US country a more countercyclical fiscal policy enhances productivity growth more in a sector whose US counterpart is more credit-constrained (i.e. either more dependent upon external finance or displays lower asset tangibility). AHK follow Rajan and Zingales (1998) in proxying financial constraints in a non-US sector by the degree of external financial dependence or inversely by the degree of asset tangibility of the corresponding sector in the US.

Similarly, Aghion, Farhi and Kharroubi (2013), henceforth AFK, use cross-OECD cross-sector data to show that a countercyclical monetary policy, which sets high interest rates in expansions and low interest rates in recessions, enhances productivity growth more in sectors whose US counterparts are more credit-constrained or more liquidity-constrained (thus they again rely on the Rajan-Zingales methodology). And indeed AFK show that a more countercyclical monetary policy is more growth-enhancing when competition is high: indeed when competition is low, large rents allow firms to stay on the market and reinvest optimally, no matter how funding conditions change.

The AFK analysis raises a number of issues. First, growth may affect the ability to cut interest rates in bad times. Second, the AFK analysis is based on data observations for the 1999–2005 period. Yet this sample period lies within what is known as the great moderation period, over which business cycle volatility in advanced economies was rather low. In this context, it is arguable that the cyclical pattern of monetary policy, to the extent it matters in general, is likely to have made less of a difference when business cycle volatility is contained. To push the argument to the limit, when business cycle volatility is zero, the cyclical pattern on monetary policy just becomes irrelevant (and meaningless).

To respond to these objections, Aghion, Farhi and Kharroubi (2018), henceforth AFK2, investigate a more “turbulent” period, namely the European sovereign debt crisis. This crisis started by the end of 2009 as several governments of Euro Area countries (most notably Greece, Portugal, Ireland, Spain and Cyprus) were facing increasing difficulties to repay or refinance their sovereign debt or to bail out over-indebted banks. The most decisive policy decision by the ECB was on 6 September 2012, when the ECB launched its so-called Outright Monetary Transactions (OMT) program. The OMT was a commitment by the European Central Bank to buy government debt (acting as a monetary backstop) under some strict conditionality. OMT was targeted at relatively short maturity bonds. Yet, its announcement was followed by massive changes in long-term government bond yields, beyond and above what had been expected.

What AFK2 then do is to look at the effect of the unexpected change in government bond yields between before and after OMT, on growth and employment across sectors in a selected set of Euro Area countries, some which were directly hit by the sovereign debt crisis (Belgium, Italy, Portugal and Spain) and others were not (Austria, France, Germany). They use interest rate forecasts from the OECD Economic Outlook publication to compute the unexpected change in each Euro Area long-term government bond yields following the announcement of the Outright Monetary Transactions (OMT) program and regress industry growth on: (1) the country-level unexpected change in long-term government bond yields following OMT; (2) sectoral indebtedness; (3) the interaction between the two; (4) the triple interaction between the unexpected change in bond yields, sectoral indebtedness, and the country-level degree of product market competition. AFK2 show that the drop in unexpected bond yields following OMT has a more positive effect on sectoral growth in more leveraged sectors. This latter result is particularly interesting as it points to a strategic complementarity between a more proactive monetary policy on the one hand and a more active competition policy on the other hand.

More generally, this vindicates the view put forward by the President of the European Central Bank (ECB), Mario Draghi, when he declared at the 2014 Economic Policy

Symposium in Jackson Hole that he could only do half the work by relaxing monetary policy and that Member States would have to do the other half by implementing structural reforms. Similarly, one should look at how product market competition interacts with fiscal policy, drawing the parallel with AKF2's analysis of how product market competition interacts with monetary policy. In particular one may want to revisit the debate on the multiplier, introducing market structure as an interactor. But also we may want to look at how fiscal policy can affect macroeconomic activity also through its potential induced effects on product market competition.

5 GROWTH, CREDIT CONSTRAINTS, AND INEQUALITY

5.1 Concepts

The important idea that the presence of credit constraints introduces a negative relationship between wealth inequality and growth, goes back to the seminal contributions of Greenwood and Jovanovic (1990), Banerjee and Newman (1993), and Galor and Zeira (1993). In this section, we briefly discuss the relationship between inequality and credit constraints within the context of a Schumpeterian growth model.⁸

Consider an economy in which wealth is distributed across individuals according to some cumulative function $G(\omega)$ with mean wealth W . There is one good and one innovation technology in the economy. Innovating requires a minimum investment of K , but then the probability of innovating is aK tomorrow, where a is the talent level of the entrepreneur investing in R&D. Assume that a is distributed uniformly on the interval $[0, 1]$ and assume that talent is distributed independently of wealth.

Individuals with wealth below K must borrow in order to innovate. Let r denote the interest rate. Every entrepreneur with talent $a \geq 1 + r$ will want to borrow in order to invest. Now, if there is not enough supply of capital in the economy to make it worthwhile for everyone to invest, in particular if $W < K$, the interest rate will have to clear the capital market.

Consider first the case where credit markets are perfect, that is, no one faces credit constraints and thus can always borrow if she considers it profitable to do so. Then, only individuals with sufficiently high productivity a will invest, the other individuals will lend them their wealth. In particular, the marginal investor's talent a^m will be such that:

$$(1 - a^m)K = W$$

Or:

$$a^m = 1 - \frac{W}{K},$$

⁸ For literature reviews of the relationship between finance and inequality, see Aghion, Caroli, and Gracia-Penalosa (1999) and Demirgüç-Kunt and Levine (2009).

and the market clearing interest rate will be $1 + a^m$.

The aggregate probability of innovation is then given by:

$$P = \int_{a^m}^1 K da = \left(\frac{1}{2} - \frac{(a^m)^2}{2}\right) K.$$

Now, let us introduce credit constraints. More specifically, suppose that individuals with wealth W can only borrow a multiple vW of their wealth. The presence of credit constraints means that not everyone has the option of investing: in order to invest K , wealth has to be at least $\frac{K}{v}$. The aggregate probability of innovation in this case is given by:

$$P^c = \int_{\omega \geq \frac{K}{1+v}} \int_{a^m}^1 aK da = \left[1 - G\left(\frac{K}{1+v}\right)\right] \left[\frac{1}{2} - \frac{(a^m)^2}{2}\right] K,$$

which is, of course, strictly less than in the absence of credit constraints.

Now consider the special case where all individuals have the same wealth. Then, even with credit markets imperfections, if the capital market clears the outcome will be as if the capital market was working perfectly. This is because if anyone is using the capital, this must include the most productive individuals, since those are willing to pay more than anyone else for capital, and those are the same individuals who would have done the investing absent credit constraints.

In other words, the reason credit constraints are detrimental to innovation and growth in the above example is because some richer but less talented individuals can bid capital away from poorer but more talented individuals. The central point is that lenders do not care, per se, about what borrowers do with the money. They care about getting paid back with enough interest to compensate for risk. Thus, lenders might prefer to lend to less productive individuals with greater collateral, which will impede innovation and growth.

5.2 Evidence

A large and growing body of empirical research examines the impact of improvements in the financial system on both poverty and income inequality. As summarized in Demirgüç-Kunt and Levine (2009), researchers using a diverse set of methodologies typically find that improvements in the financial system exert a disproportionately positive impact on the poor. For example, using cross-country, panel data, Beck, Demirgüç-Kunt, and Levine (2007) find that financial development disproportionately boosts the incomes in those in the lower quintile of the distribution of income, and reduces the proportion of people living in extreme poverty. They show that these results hold even when controlling for the average growth rate in the economy, indicating that these results do not simply reflect overall economic gains from financial development; they indicate the especially pronounced link between finance and the incomes of the poor. Looking across the states of the USA, Beck et al. (2010) discover that exogenous changes in bank regulations that improved the operation of state banking systems reduced income inequality, while Levine et al. (2014) show that financial development also reduced the racial wage gap

between blacks and whites across US states. At a more micro level, researchers find that easing credit constraints reduces poverty and disproportionately expands the economic opportunities of those at the bottom of the income distribution (e.g., Jacoby, 1994; Jacoby and Skoufias, 1997), and a growing body of work explores the impact of access to financial services on economic development (e.g., Beck, Demirgüç-Kunt, and Peria, 2007).

6 CONCLUSION

In this chapter, we have introduced financial constraints into the Schumpeterian growth paradigm. This has allowed us to generate predictions about: (1) the effect of financial development on innovation-led growth and convergence; (2) credit constraints as a potential source of cross-country divergence; (3) how credit constraints impact the relationship between macroeconomic volatility and innovation-led growth; and (4) the impact of financial development on income inequality in general and poverty in particular.

We think we have only touched upon the issue of finance and innovation-led growth, and that much more work should and will be done in this area. Without prejudging how this area will develop over the next years, here are some open issues that await further thought. First, researchers could better explore conceptually and empirically the dynamic relationship between financial regulations, credit constraints, innovation, and the distribution of income. Easing financial constraints could increase the returns to high human capital activities, boosting inequality. Dissecting these features would materially improve our understanding of the effects of financial development. Second, researchers could continue the exploration of the interplay between credit constraints, growth, and firm dynamics. Following Klette and Kortum (2004),⁹ a new generation of Schumpeterian growth models have been developed, where innovations come from both entrants and incumbents, and more importantly, firms are defined as a collection of production units. Successful innovations by incumbents allow them to expand in the product space, whereas creative destruction on any existing line leads the incumbent firm to shrink. Introducing credit constraints in this framework can have two opposite effects on aggregate innovation and growth: on the one hand, it may prevent potentially good innovators from entering the market, which in turn is detrimental to aggregate innovation and growth. On the other hand, credit constraints may make it harder for less efficient incumbent firms to remain on the market and prevent the entry and expansion of more efficient innovators. This in turn may increase aggregate innovation and growth. It would be interesting to see under which circumstances the positive effect of credit constraints dominates if at all, and whether the overall effect of credit constraints on aggregate innovation may end up being non-monotonic. A third extension would be to further explore the interaction between financial and technological innovation. These and other potential explorations of the relationship between finance, financial constraints, and innovation-led growth, are left for future research.

⁹ See in particular, Akcigit and Kerr (2016) and Acemoglu et al. (2016).

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