Schumpeterian Banks: Credit Reallocation and Capital Requirements*

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Abstract

Capital reallocation from unprofitable to profitable firms is a key source of productivity gain in an innovative economy. We present a model of credit reallocation and focus on the role of banks: Weakly capitalized banks hesitate to write off non-performing loans to avoid a violation of regulatory requirements or even insolvency. Such behavior blocks credit to expanding industries and results in insufficient credit reallocation across sectors and a distorted capital allocation. Reducing the cost of bank equity, tightening capital requirements, and improving insolvency laws relaxes constraints and mitigates distortions.

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1 Introduction

One of the main economic functions of the financial sector is to efficiently allocate capital by channeling funds towards those firms that can use them most productively. Banks and other financial intermediaries perform functions like the credit risk analysis, monitoring of borrowers, and the liquidation of loans with poor prospects. The latter may cause the closure of firms without a viable business model. At the same time banks are able to recover capital which would otherwise be blocked, and to reallocate the released funds to new ventures. This role of finance connects to Schumpeter's idea of 'creative destruction' and fosters innovation and growth. Only strong and well capitalized banks can adequately fulfill this function. The current efforts to strengthen banks' balance sheets and capital structure need to be seen in this light as emphasized by Mario Draghi:[1] 'Frontloading banking sector repairs ... should in turn facilitate the Schumpeterian process of creative destruction in the economy at large – and not only by helping credit flow to younger firms, but also by facilitating debt resolution for older ones.'

Weakly capitalized banks, in contrast, tend to delay the necessary restructuring of non-performing loans because the write-offs would lead to a violation of regulatory constraints or even to insolvency. Banks instead continue lending to quasi-insolvent borrowers hoping that they will recover and eventually pay back. Such behavior distorts capital allocation, slows down the expansion of productive firms and leads to congested product markets. The crisis of the Japanese economy in the 1990s may serve as an example. Since many Euro area banks currently face the need to restructure their loan portfolios, economists and policy makers are increasingly concerned that a similar scenario might evolve in some European economies with weak banks and a high share of non-performing loans. Such banks could curtail new lending and delay the recovery. Mario Draghi warned: 'Put bluntly, this would create "zombie" banks that do not lend, and the longer this persists, the longer credit conditions will interfere with the process of creative destruction described by Schumpeter. The "churn" process between firms entering and exiting the market that

[1] Speech at the presentation ceremony of the Schumpeter Award, Vienna, March 13, 2014.

is a crucial driver of productivity would be disrupted.'

In the present paper, we investigate how banks contribute to creative destruction by reallocating credit. The model emphasizes the role of capital structure of banks in financing firms which operate in expanding and downsizing parts of the economy. After investment projects are initiated, banks observe the success probabilities which are often quite low in the downsizing sector, indicating poor prospects. The bank must then decide whether to continue lending or not. If it liquidates a loan, it must absorb some losses but can reallocate recovered funds to more promising projects in the innovative sector. However, the losses from writing off non-performing loans impair bank equity. At the same time, investors are hesitant and recapitalization is difficult when a bank most write off many non-performing loans. When equity capital is expensive, the regulatory capital requirement is binding and puts a constraint on credit reallocation. Banks must trade off the benefit of more aggressive credit reallocation against the cost of holding a voluntary capital buffer. In the end, they tend to liquidate too few non-performing loans and to engage in 'Zombie lending' to firms which should be liquidated. Credit decisions might distort firm entry and sectoral capital allocation. These problems are more severe whenever equity requires a high premium, capital requirements are low, and loan liquidation is costly.

The paper builds on two established empirical facts in the finance and growth literature. First, capital and labor allocation is crucial for growth and productivity. Bartelsman, Haltiwanger and Scarpetta (2013) estimate that labor productivity in the U.S. manufacturing sector is 50 percent higher than it would be in case labor shares were randomly allocated within industries. The importance of reallocation for productivity growth is also documented at the industry level, for example, by Olley and Pakes (1996) for the telecommunications equipment industry and by Foster, Haltiwanger and Krizan (2006) for the retail trade industry. These results are broadly consistent with M&A research which finds that the productivity of an asset tends to increase after its sale and subsequent acquisition (e.g., Maksimovic and Phillips, 2001; Schoar, 2002). A large amount of financial assets is reallocated each year. Eisfeldt and Rampini (2006) estimate that capital reallocation measured by sales and acquisitions of property, plants and equipment accounts for roughly one quarter of investment. Dell'Ariccia and Garibaldi (2005) study the gross credit flows resulting form simultaneous credit expansion and contraction of banks in the United States. They show that sizable flows coexist at any phase during the business cycle. These flows are highly volatile. The volatility is considerably larger than that of GDP. Herrera, Kolar and Minetti (2011) examine the reallocation of credit across firms which is quantitatively important, highly volatile and slightly procyclical. Credit is mainly reallocated across firms of similar size, industry and location.

Second, there is substantial empirical evidence that financial development improves the efficiency of the capital allocation and fosters economic growth (e.g., King and Levine, 1993a, 1993b; Beck, Levine and Loyaza, 2000; Beck and Levine, 2004). Typically, the effect of size-related measures like, for example, private credit or stock market capitalization on income, growth and productivity is estimated in reduced form using cross-country data. In an influential paper, Rajan and Zingales (1998) explore sectoral differences of the impact of financial development depending on industries' external financing needs. Given the finding that productivity crucially depends on the capital and labor allocation, the 'Schumpeterian role' of finance provides one explanation for the observed effect on growth and productivity. In a seminal contribution, Wurgler (2000) shows that countries with more developed financial markets as measured by size and institutional characteristics are better able to increase investment in growing and to withdraw funds from declining industries. More precisely, financial development increases the elasticity of investment to value added in an industry. If value added increases by one percent, investment rises by only 0.22 percent in a country with a weakly (Indonesia) and by 0.99 percent in a country with a highly developed financial sector (Germany).

An alternative approach exploits policy changes. Jayaratne and Strahan (1996) study the deregulation of bank branching restrictions across U.S. States between the 1970s and 1990s. They show that liberalization improved lending quality and investment efficiency.

Acharya, Imbs and Surgess (2011) examine the impact of branch deregulation on allocative efficiency focusing on the sectoral composition in U.S. states. They apply a mean-variance portfolio approach to sectoral returns and derive the efficient sector mix for each state. Subsequently, they estimate how deregulation affects the distance between the actual and benchmark allocation. The findings suggest that deregulation improved efficiency through diversification and lower output volatility such that the sector mix moved closer to the efficient benchmark. Bertrand, Schoar and Thesmar (2007) study the real effects of banking reforms in France in 1985 that significantly reduced government interventions in banks' lending decisions and involved abolishing subsidized loans and credit growth restrictions or the privatization of banks. Exploiting differences in firms' bank-dependence, they find that the reform induced banks to cut loans to poorly performing firms more often. At the firm level, they observe an increase in allocative efficiency through higher reallocation and exit rates.

Financial frictions affect reallocation within firms. Using plant-level data, Giroud and Mueller (2015) document spillovers for plants of financially constrained firms with positive effects on aggregate investment and employment. If one plant receives an investment opportunity, the firm withdraws capital and labor from other, less productive plants to mobilize funds. This leads to an increase in firm-wide productivity. However, there is no evidence for such intra-firm reallocation in financially unconstrained conglomerates.

A weak financial sector may become an obstacle for reallocation. Caballero, Hoshi and Kashyap (2008) analyze the distortions because of lending to so-called 'Zombie' firms in Japan. The massive decline in asset prices 1990 impaired collateral values. Banks were, however, reluctant to restructure non-performing loans as write-offs would have further weakened their already low capitalization. Instead, they continued lending to de facto insolvent borrowers. A large share of such 'Zombie' firms in an industry is associated with reduced job creation and destruction and lower TFP growth. Congestion in product markets reduces the profits of productive firms. Consequently, employment growth and investment of healthy firms significantly decrease in the share of 'Zombie' firms. The authors calculated a cumulative loss of investment over a ten year period equal to 17% of capital, corresponding to an investment volume of one year.

Despite of this large body of empirical evidence, only few theoretical contributions examine the 'Schumpeterian role' of finance. The finance-growth literature usually relies on reduced-form models of the financial sector. King and Levine (1993b) develop an endogenous growth model where financial intermediaries evaluate entrepreneurs and finance their innovative activities. They show that financial sector distortions reduce growth. Almeida and Wolfenzon (2005) study the effect of external finance on the equilibrium capital allocation. External financing needs improve the capital allocation as more intermediate or unprofitable projects are liquidated. The larger supply reduces the cost of capital, which allows financially constrained entrepreneurs with highly productive investments to attract additional funds. Eisfeldt and Rampini (2006) analyze the cyclical properties of reallocation. They show that capital illiquidity modeled as adjustment costs explain the observed procyclicality of reallocation which contrasts with its apparently countercyclical benefits. Hence, this friction hampers reallocation exactly when it promises the largest benefits. In the theoretical banking literature, capital reallocation does usually not take center stage but the topic relates to the literature on credit decisions of banks that share some similarities with loan liquidation. Inderst and Mueller (2008) model a bank's decision whether to finance a risky project based on a noisy signal. They characterize the optimal capital structure of banks, which ensures that the credit decision is first-best.

The novel aspect and key contribution of the paper is that it explicitly introduces and analyzes the process and the determinants of how banks reallocate credit to more productive uses and innovative activities. We specifically explore the role of banks' capital structure that is at the core of current regulatory reforms. So far, the focus of the theoretical finance and growth literature has mainly been on firms and entrepreneurs and not on banks or other financial intermediaries. Given the importance of reallocation as a driving force of productivity growth and substantial evidence that financial factors matter, a theoretical model of banks' 'Schumpeterian' role adds value. Theory characterizes the central mechanism of credit reallocation and sheds light on the main determinants such as refinancing or liquidation costs or pull factors such as new investment opportunities in the innovative sector. Our theoretical approach also identifies the distortions that could potentially hamper reallocation and should therefore be informative in designing targeted policy options. The paper first sets out the model, then investigates efficiency properties, explores the comparative static effects chocks to the reallocation process and finally wraps up with some concluding remarks.

2 The Model

All agents are risk-neutral. Endowments are entrepreneurial labor of mass 1 and capital owned by investors. Entrepreneurs can either start an x-firm with a high-risk high-return project (a more radical innovation) or a y-firm with a more opaque, more uncertain project.[2] Both firms thus produce the same *numeraire* good but with different technology.

Banks intermediate investor funds and transform them into business credit. In an interim period, they observe a performance in the downsizing y-sector, liquidate unprofitable firms and reallocate funds to firms in the expanding x-sector. The economy thus consists of a downsizing y-sector where part of the firms are liquidated when receiving an unfavorable shock, and an expanding x-sector. Reallocation of capital from the declining industry finances new x-firms in addition to original startups.

Firms: Each firm is run by 1 entrepreneur and needs 1 unit of capital (loan). In the x-sector, a firm produces x units of output with probability p, and 0 with probability $1-p$. Innovative firms are subject to high risk. Capital fully depreciates and cannot be used elsewhere. The liquidation value is zero. Since entrepreneurs have no own funds, investment must be financed with bank credit. The firm pays gross interest i_x. The bank's

[2]Since goods are perfect substitutes, the sectoral interpretation refers to more or less innovative projects in terms of technology.

expected interest earnings is pi_x and expected firm profit amounts to

$$\pi_x = p\left(x - i_x\right). \tag{1}$$

Firms in the downsizing y-sector receive a loan of size 1 at a gross interest i_y. They produce y if they succeed and zero if they fail. Projects are more opaque and uncertain in that they are successful with a heterogeneous probability. In the interim period, the true success probability $q' \in [0,1]$ of each firm is revealed and observed by the bank.

The average success probability is $E[q'] = \int_0^1 q' dF(q') = 1/2$ when the distribution is uniform. Unprofitable firms with little chances for success $q' < q$ are liquidated where q is the pivotal type. A share $\int_0^q dF(q') = q$ of firms is liquidated and the remaining part $\int_q^1 dF(q') = 1 - q$ continues. After continuation, they survive with probability q' and produce output y, or fail with probability $1 - q'$ and produce nothing. Ex ante, the unconditional success probability of an entrant is

$$\hat{q} = \int_q^1 q' dF(q') = \frac{1 - q^2}{2}, \quad \frac{d\hat{q}}{dq} = -q. \tag{2}$$

The success probability conditional on continuation (i.e., on not being liquidated) is

$$\bar{q} = E[q'|q' \geq q] = \frac{\int_q^1 q' dF(q')}{1 - q} = \frac{1 + q}{2}, \quad \frac{d\bar{q}}{dq} = \frac{1}{2}. \tag{3}$$

With a uniform distribution, the two probabilities are related by $\hat{q} = (1 - q)\,\bar{q}$.

Based on the observed signal the interim period, the bank terminates a loan if it is unlikely to be repaid. Given a cut-off q, the firm is liquidated and the entrepreneur gets a zero payoff whenever $q' < q$. Hence, q is the liquidation probability, and $1 - q$ is the probability of continuation. Conditional on continuation, expected profit is

$$\pi_y = \bar{q}\left(y - i_y\right). \tag{4}$$

Banks raise deposits d and equity e, paying returns r and $\rho > r$. They lend to firms in both sectors. When receiving a bad performance signal, they liquidate non-performing loans to y-firms, collect liquidation values and lend the proceeds to new x-sector firms.

Banks may charge different lending rates i_x and i'_x on initial and reallocated loans in the x-sector. Expected profits are

$$\pi_b = p i_x n_x + \pi_{by} n_y - rd - \rho e, \quad \pi_{by} \equiv \bar{q} i_y (1-q) + p i'_x (1-c) q, \quad d = n_x + n_y - e. \quad (5)$$

We assume that entrepreneurs who failed in the y-sector get a second chance for a fresh start in the x-sector.[3] In the liquidation process, the bank can extract only $1-c$ of the loan and incurs a loss c. Liquidating a fraction q of y-firms yields total liquidation proceeds $(1-c)\, q n_y$ which become available for new lending. Since loan size is one, this is also the mass of additional x-projects that get funded. An entrepreneur initially entering the y-sector faces three events: (i) continue with probability $1-q$; (ii) get liquidated and try a fresh start with an x-project with probability $(1-c)\, q$; and (iii) get liquidated and fail to get a second chance with probability cq. Liquidated firms are rationed by the limited availability of released funds. Figure 1 illustrates.

Credit reallocation results from liquidation. Reallocated credit volume is $(1-c)\, q n_y$. After reallocation, the number of x- and y-firms is

$$n'_x = n_x + (1-c)\, q n_y, \quad n'_y = n_y - q n_y. \quad (6)$$

Entrepreneurs: When starting an x-firm, expected profit is π_x. When starting a y-firm, expected profit depends on the performance signal received after initial investment. The firm continues with probability $1-q$ only if the signal is good enough, and expects a profit π_y in this event. With probability q, the firm gets liquidated, and the entrepreneur may get a chance for a fresh start or not. She gets a second chance with an x-project and becomes a 'serial' entrepreneur with probability $(1-c)\, q$, yielding expected profit $\pi'_x = p\,(x - i'_x)$. Due to a different lending rate, it differs from the profit firms which directly entered the x-sector. With probability cq, the entrepreneur is terminally out. In

[3]Fresh-start policy is indeed an important feature of insolvency laws, see White (2011), and Gompers et al. (2010) find substantial evidence on serial entrepreneurship.

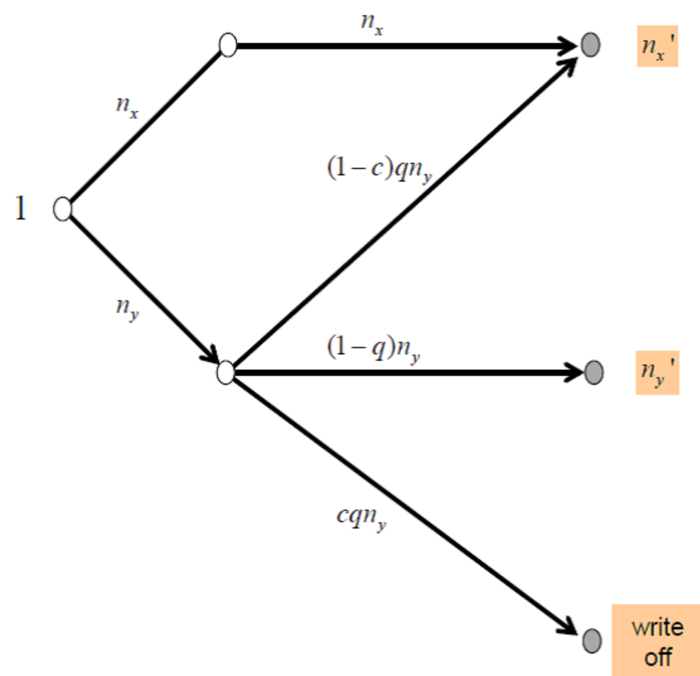

Figure 1: Credit Reallocation

the beginning, expected profit of starting a y-firm thus amounts to

$$\bar{\pi}_y = \pi_y \cdot (1-q) + \pi'_x \cdot (1-c)\, q. \tag{7}$$

We picture an economy where more radical innovations offer larger profit opportunities, $\pi_x > \bar{\pi}_y$, see the Appendix.

In the beginning, entrepreneurs do some initial R&D and develop a business plan. They may opt for a more radical innovation strategy going for a high-risk, high-return x-project or pursue a more opaque and uncertain y-project with many possible outcomes (in terms of the success probability q'). Creating an x-project requires either high talent or experience acquired from serial entrepreneurship. We assume that innovative talent $h \in [0,1]$ is heterogeneous and uniformly distributed among entrepreneurs. High talent means low entry cost in terms of R&D effort, $\omega(h)$, which is increasing in type h, $\omega'(h) > 0$. Imposing Inada conditions $\lim_{h\to 0}\omega(h) = 0$ and $\lim_{h\to 1}\omega(h) = \infty$ assures an interior solution for the discrete innovation strategy. If n_x is the pivotal type opting for an x-

project, the uniform distribution yields a mass of x-entrants

$$n_x = \int_0^{n_x} dh, \quad \Omega(n_x) = \int_0^{n_x} \omega(h)\, dh. \tag{8}$$

The second term Ω is aggregate entry cost in terms of an R&D effort which rises with the cost of the marginal entrepreneur, $\Omega'(n_x) = \omega(n_x)$.

An entrepreneur's welfare is expected income minus effort cost. The R&D effort of a y-project is normalized to zero. An effort cost is required only if an x-project is developed without any prior entrepreneurial experience. An x-project may also be created by serial entrepreneurs in which case initial effort is replaced by experience, see (7). Given these assumptions, an entrepreneur of type h opts for an x-project if $\pi_x - \omega(h) \geq \bar{\pi}_y$, and else opts for a less ambitious innovation strategy with a y-project. Clearly, only the types with more innovative and entrepreneurial talents go for the more radical innovation of an x-project right from the beginning. The occupational choice condition splits up entrepreneurs by

$$\pi_x - \omega(n_x) = \bar{\pi}_y. \tag{9}$$

Investors are endowed with capital I which they invest in deposits, bank equity and an alternative investment opportunity A yielding a return r. Investor profits are

$$\pi_i = \rho e + rd + rA, \quad e + d + A = I, \quad \rho = \theta + r. \tag{10}$$

Assets are perfect substitutes up to an equity premium θ. In consequence, the supply of deposits and equity is perfectly elastic at rates r and ρ. The equity premium compensates for investor effort on oversight and management, giving welfare $\pi_i - \theta e$.

Equilibrium: The initial sectoral allocation of firms, $n_x + n_y = 1$, results from occupational choice and bank lending. Each x-firm survives with probability p and produces expected output px per firm. Downsizing of the y-sector and credit reallocation of released funds further expands the x-sector. Using (6), aggregate output $X = pxn'_x$ and $Y = \bar{q}yn'_y$ after reallocation is equal to expected output prior to reallocation,

$$X + Y = pxn_x + \bar{y}n_y, \quad \bar{y} \equiv px(1-c)q + \bar{q}y(1-q). \tag{11}$$

We note $\bar{\pi}_y = \bar{y} - \pi_{by}$ for later use. Aggregate income after reallocation equals

$$\Pi = \pi_x n_x + \bar{\pi}_y n_y + \pi_b + \pi_i, \tag{12}$$

and is spent on the numeraire goods. Substituting profits and using (11) yields

$$\Pi = X + Y + rA. \tag{13}$$

Aggregate demand is equal to total income Π and matches supply of x- and y-sector firms plus output rA of the alternative technology in (10). Alternative investment $A = I - e - d$ is residually determined and reflects capital market clearing.

3 Equilibrium Analysis

This section studies equilibrium. We start without a capital constraint and establish a first best allocation. In the next step, we add a regulatory constraint, compute the market equilibrium and explore welfare properties to identify the main distortions. Finally, we derive comparative static restults to discuss policy options.

3.1 Unconstrained Reallocation

The timing is: (i) initial lending and credit contracts, (ii) get the performance signal for y-firms and decide on liquidation. Solution is by backward induction. We first solve for optimal liquidation and credit reallocation, conditional on previous lending and interest rates. Then we proceed with initial lending decisions which anticipate subsequent results.

Credit Reallocation: At the reallocation stage, the bank observes the signal q' of y-firms and decides whether to continue or terminate the loan. It reallocates released funds to new x-firms. Liquidation choice maximizes expected return on all initial loans to y-firms. Using the definitions of q and $\bar{q}$ in (3), the optimal cut-off solves

$$\pi_{by} = \max_{q} \int_q^1 i_y q' dF(q') + \int_0^q p i'_x (1-c)\, dF(q'). \tag{14}$$

The first term corresponds to firms with a sufficiently good signal. The credit is continued since they are likely to repay the loan. The second term relates to firms with very low survival probability which are unlikely to repay the loan. They are liquidated and funds are reallocated to new x-projects which generate expected interest earnings pi_x'. Except for the survival probability q', everything else is symmetric. Using the Leibniz-rule, a bank's optimal choice of the cut-off satisfies

$$qi_y = pi_x' (1-c) \quad \Rightarrow \quad q = pi_x' (1-c) / i_y. \tag{15}$$

When liquidating a firm, the bank must write off a part c of the outstanding credit. It can extract a liquidation value of only $1-c$ which reflects investor protection and bankruptcy laws as well as the bank's expertise. Lending these proceeds to x-projects gives expected interest earnings $pi_x' (1-c)$. Instead, the credit earns expected interest qi_y if continued. The cut-off type of the marginal firm is chosen such that the bank is just indifferent between these two options.

Lending: Initially, the bank gives unit loans to x- and y-projects and is a price taker on the deposit market. Collecting terms, expected profits are seen to be linear in loans and decreasing in equity:

$$\pi_b = [pi_x - r] \cdot n_x + [\pi_{by} - r] \cdot n_y - \theta e, \quad \pi_{by} \equiv \bar{q} i_y (1-q) + pi_x' (1-c) q. \tag{16}$$

Since equity has no advantage but requires a premium θ, a bank chooses $e = 0$.

In competing for loans, banks cut loan rates until break-even (Bertrand competition). More precisely, competitive banks offer credit contracts - they set lending rates - to attract firms from both sectors. To successfully compete, the contract is designed to maximize expected firm profits π_x and $\bar{\pi}_y$ subject to a break-even constraint. A bank could otherwise steal business from other banks by offering a contract yielding slightly higher profits. In consequence, competitive banks make zero profits on both types of loans and are willing to supply any quantity. The sectoral allocation n_x and n_y is pinned down by the demand side.

When extending an x-loan, expected repayment just covers the refinancing cost,

$$i_x = \frac{1}{p} \cdot r. \tag{17}$$

In case of a y-start-up, the bank sets two interest rates: i_y if the firm continues and i'_x if credit is reallocated and the entrepreneur starts new in the x-sector. Again, lending rates maximize expected profit $\bar{\pi}_y$ subject to the constraint that total earnings (either from continuation or liquidation and relending) must match at least the bank's refinancing cost, $\pi_{by} \geq r$. With competition, the bank cannot do better than break-even. The entrant thus extracts the entire joint surplus, $\bar{\pi}_y = \bar{y}(q) - r$ which is exclusively affected by the liquidation cut-off q. In competing for loans, the bank first maximizes the joint surplus by choosing the liquidation cut-off q, and in a second step scales down loan rates until break even. Maximizing the joint surplus yields

$$\bar{\pi}_y = \bar{y}(q) - r, \quad \frac{d\bar{\pi}_y}{dq} = -qy + px(1-c) = 0 \quad \Rightarrow \quad q = px(1-c)/y. \tag{18}$$

Since it maximizes the joint surplus, the optimal cut-off is first-best, $q = q^*$. The lending rates i'_x and i_y jointly affect the bank's liquidation decision as in (15). To support the optimal liquidation decision, interest rates must be set to satisfy the ratio

$$pi'_x(1-c)/i_y = q^* = px(1-c)/y \quad \Leftrightarrow \quad i'_x = i_y \cdot x/y. \tag{19}$$

The interest rate on reallocated credit must be higher than the rate on continued credit (due to $x > y$). In a second step, the bank proportionately scales down loan rates to shift the surplus towards entrepreneurs until it hits break-even. Substitute (15) into the break-even constraint to solve for i_y in terms of the optimal q yields $\bar{q}i_y(1-q) + i_y q^2 = r$ which is rearranged to yield

$$i_y = \frac{2}{1+q^2} \cdot r, \quad i'_x = i_y \frac{x}{y} = \frac{2}{1+q^2} \frac{x}{y} \cdot r, \tag{20}$$

where q is the first-best cut-off in (18). Lending rates exceed the deposit rate and satisfy $i'_x > i_y > r$. The first inequality is due to $x > y$ and the second one results from $q < 1$ which requires an assumption on returns and liquidation cost, $px(1-c) < y$.

Industry structure: Entrepreneurs start firms with a more or less innovative technology whichever is more profitable. When pursuing a radical innovation, expected profit is π_x. When entering the y-sector, the entrepreneur could succeed, fail and get a second chance, or fail completely. Relative expected profits $\pi_x > \bar{\pi}_y$ do not change when entry shifts from one to the other sector. Industrial structure is determined by occupational choice and driven by heterogeneous entry costs, see (9), yielding the equilibrium n_x.

Welfare: A type h-entrepreneur expects welfare $v_h = \pi_x - \omega(h)$ when starting an x-project. Collecting all x-entrants gives aggregate welfare $\pi_x n_x - \Omega(n_x)$. We also suppose that y-startups getting a second chance have accumulated entrepreneurial experience which replaces the initial effort of fresh x-entrants. Since there are no other costs than effort of fresh x-entrants and equity investors, aggregate welfare is simply $V = \Pi - \Omega(n_x) - \theta e$. The social planner directly chooses the allocation and maximizes aggregate welfare subject to the resource constraints $n_x + n_y = 1$ and $d + e + A = I$,

$$V = \max_{q,n_x,e} \Pi - \Omega(n_x) - \theta e, \tag{21}$$

where $\Pi = pxn_x + \bar{y}n_y + rA$ and $\bar{y}(q)$ by (11-13). Obviously, equity lowers welfare because of the effort cost, $\frac{dV}{de} = -\theta < 0$, so that $e^* = 0$ as in the market equilibrium. The first-best allocation q^* and n_x^* must satisfy optimality conditions

$$\frac{dV}{dq} = [px(1-c) - q^* y]\, n_y = 0, \quad \frac{dV}{dn_x} = px - \bar{y}(q^*) - \omega(n_x^*) = 0. \tag{22}$$

Comparing with the bank's choice of the liquidation cut-off $q = pi_x'(1-c)/i_y$ and lending rates in (20), and with the occupational choice condition (9) implies:

Proposition 1 *If credit reallocation is unconstrained, the market equilibrium is efficient.*

Proof. Substituting for q in (22) using (18) yields $dV/dq = 0$ such that $q = q^*$. Substituting for n_x in the second condition using $\omega(n_x) = \pi_x - \bar{\pi}_y$ from (9) together with $\bar{\pi}_y = \bar{y}(q) - \pi_{by}$ and $\pi_{by} = pi_x = r$ yields $dV/dn_x = 0$ such that $n_x = n_x^*$. ■

Competitive banks propose a loan contract such that subsequent liquidation maximizes the joint surplus, and then scale down interest rates until they hit break-even. This is equivalent to welfare maximization. Similarly, zero profits of banks and investors imply that entrepreneurs capture the entire joint surplus. Given uniform refinancing costs r, the sectoral difference in joint surplus corresponds to the output difference in (22). Entry is therefore first best as well.

3.2 Constrained Reallocation

Liquidating firms and reallocating credit impairs bank capital. When a bank liquidates, it must write off part of the credit and needs equity capital to absorb this loss. The bank risks to violate regulatory requirements or would even be insolvent if equity turned negative. In this situation, a bank with opaque assets in place is typically unable to rapidly issue new equity due to long delays and dilution costs, as is commonly assumed in the literature on capital regulation (e.g., Repullo and Suarez, 2013).

3.2.1 Market Equilibrium

Regulatory Constraint: The constraint on equity requires that a bank's capital ratio must at no point fall short of the minimum capital requirement k. Each bank needs to raise enough equity ex ante to ensure that its equity position after absorbing liquidation losses still satisfies the capital requirement,

$$e - cqn_y \geq k \cdot \left(n'_x + n'_y\right). \tag{23}$$

Equity net of total liquidation cost, $e - cqn_y$, must not fall short of the minimum capital requirement which is a fraction k of total assets after reallocation. Assets consist of initial and new credit $n'_x = n_x + (1-c)\,qn_y$ to x-firms and remaining credit $n'_y = (1-q)\,n_y$ to y-firms. Credit reallocation involves two effects: Liquidation lowers both equity (by cqn_y) and the required capital (by $kcqn_y$). The second effect emerges because the liquidation cost reduces assets, $n'_x + n'_y = n_x + n_y - cqn_y < n_x + n_y$, and frees up equity. The first effect dominates except for an all equity-financed bank. The net loss of equity during credit reallocation is positive and tightens the constraint.

A special case of (23) with qualitatively similar implications is a solvency constraint with $k = 0$. Banks with negative equity are not allowed to operate. Reallocation requires positive equity to absorb liquidation costs. Otherwise the bank would become insolvent.

Reallocation and capital structure: Banks choose the liquidation rate and raise equity to maximize expected profit, conditional on loan rates. Given perfect competition, banks compete for business by reducing loan rates until they break even. Using the financial identity $d + e = n_x + n_y$ in (5) yields the constrained problem of the first stage

$$\pi_b = \max_{q,e} \left[pi_x - r\right] n_x + \left[\pi_{by} - r\right] n_y - \theta e + \lambda \cdot \left[e - cqn_y - \left(n_x + \left(1 - cq\right) n_y\right) k\right], \quad (24)$$

where $\pi_{by} \equiv \hat{q} i_y + p i'_x (1 - c) q$ is the ex ante loan value to a downsizing firm. The regulatory constraint forces banks to raise sufficient equity such that they can reallocate the desired fraction of loans in the interim period. Optimality conditions are $\lambda = \theta$ and

$$p i'_x (1 - c) - q i_y = (1 - k) \theta c. \quad (25)$$

The marginal benefit from liquidating and reallocating a loan is positive and corresponds to the marginal cost of using more expensive equity as dictated by the regulatory constraint. In the unconstrained case ($\lambda = \theta = 0$), the cutoff would be as in (15).

Lending: In the first stage, banks cut loan rates to compete for business until they hit beak-even. Using the binding capital constraint to substitute for e yields

$$\pi_b = \left[pi_x - \bar{r}\right] n_x + \left[\pi_{by} - \bar{r} - (1 - k) \theta cq\right] n_y, \quad \bar{r} \equiv (1 - k) r + k\rho = r + \theta k. \quad (26)$$

The term $\bar{r}$ is the weighted cost of capital when the bank operates at the regulatory minimum. The linearity of the problem implies zero bank profits on both types of loans (i.e., the square brackets are zero). Competition drives down lending rates until interest earnings just match refinancing costs.

Similar to the unconstrained equilibrium, banks offer a credit contract that maximizes entrepreneurial profits subject to the break-even condition. Lending rates to innovative firms are fixed by $pi_x = \bar{r}$ but they are now higher because of the use of costly equity.

To attract y-firms, competitive banks also cut loan rates i'_x and i_y until they hit the break-even condition

$$\pi_{by} = \hat{q} i_y + p i'_x (1 - c) q = \bar{r} + (1 - k) \theta c q, \quad \hat{q} = \left(1 - q^2\right) / 2. \tag{27}$$

When setting loan rates, banks must anticipate the consequences for subsequent liquidation decisions.

Competition forces banks to cede the entire joint surplus to firms. Noting the break-even condition, firm profit equals $\bar{\pi}_y = \bar{y}(q) - \pi_{by} = \bar{y}(q) - (1 - k) \theta c q - \bar{r}$ which exclusively depends on the cut-off q. Competing for firms again requires to maximize the joint surplus which adds a third condition to the system formed by (25) and (27). Intuitively, banks attract customers by leaving them higher profits. They first maximize joint surplus by choosing an optimal cut-off, and then set interest rates such that they induce the optimal liquidation decision and assure break-even. Noting $\bar{y}(q) = px(1 - c) q + \bar{q} y (1 - q)$, optimality requires a cut-off

$$q = \frac{px(1 - c) - (1 - k) \theta c}{y}. \tag{28}$$

Given q, lending rates i'_x and i_y must now solve (25) and (27). Banks must break even and the induced liquidation decision must support the optimal cut-off in (28). Solving for loan reates yields

$$i_y = \frac{2}{1 + q^2} \cdot \bar{r}, \quad i'_x = \frac{q \cdot i_y + (1 - k) \theta c}{p(1 - c)}. \tag{29}$$

Compared to the first best, banks liquidate fewer loans ($q < q^*$) as long as the equity premium is positive and the bank is not fully equity financed. Credit is only reallocated (i.e., q is positive) as long as $px(1 - c) > (1 - k) \theta c$. In another scenario describing a rigid economy, either equity or liquidation would be so costly that reallocation would be unprofitable to the bank. This imposes an upper bound on the liquidation cost, $c < px / [px + (1 - k) \theta]$, which decreases in the equity premium but increases in the capital requirement.[4]

[4]Otherwise, we would have a corner solution $q = 0$ such that $\hat{q} = E[q] = 1/2$. The break-even condition would then pin down the lending rate $\pi_{by} = i_y / 2 = \bar{r}$.

This general model nests several special cases:

- No equity premium $\theta = 0$: Equity is no more expensive than deposits. The bank can thus always choose an equity buffer large enough to absorb liquidation costs. The regulatory constraint is slack, leading to the first-best allocation. The liquidation cut-off reduces to $q = px(1-c)/y$ and the (expected) lending rates $pi_x = r$ as well as $i_y = 2r/(1+q^2)$ and $i'_x = 2rx/[(1+q^2)y]$ are first-best.

- All-equity financed bank with $k = 1$: Credit reallocation does not affect the regulatory constraint (23) since it reduces interim-period equity and the capital requirement by exactly the same amount. Although empirically not relevant, it points to high capital requirement and a low equity premium being substitutes they both effectively relax the constraint. However, lending rates are higher, $pi_x = \rho$ as well as $i'_x = 2\rho x/[(1+q^2)y]$ and $i_y = 2\rho/(1+q^2)$. The sectoral allocation is not distorted but the exclusive use of equity entails a welfare-reducing effort cost.

- Rigid economy with high liquidation costs $c > px/[px + \theta(1-k)]$: Banks consider reallocation too costly such that $q = 0$. This describes inefficient banks or a poor institutional environment.

Industry structure: As before, entry follows from occupational choice with heterogeneous entry costs. Free entry pins down the initial loan allocation n_x and n_y. Substituting for $\pi_x = px - \bar{r}$ and $\bar{\pi}_y = \bar{y}(q) - \pi_{by} = \bar{y}(q) - \bar{r} - (1-k)\theta cq$ gives

$$\omega(n_x) = \pi_x - \bar{\pi}_y = px - \bar{y}(q) + (1-k)\theta cq. \tag{30}$$

3.2.2 Welfare

For a welfare analysis, we first need aggregate income which is $\Pi = pxn_x + \bar{y}n_y + rA$ by (11) and (13) where $\bar{y} \equiv px(1-c)q + \bar{q}(1-q)y$ and $\bar{q}(1-q) = (1-q^2)/2$. The regulatory constraint is $e \geq k + (1-k)cqn_y$ by (23). If the planner is not constrained, social welfare maximization would need to solve the problem in (21), yielding the same solution is in (22), leading to $e^* = 0$ in particular.

To get constrained social welfare (second best), equity e can no longer be set to zero but must satisfy the regulatory constraint, leading to the constrained problem

$$V = \max_{q, n_x} \Pi - \Omega(n_x) - \theta \left[k + (1-k) cqn_y \right]. \tag{31}$$

Using $n_y = 1 - n_x$, a variation of the market allocation changes social welfare by

$$\frac{dV}{dq} = \left[px(1-c) - qy - (1-k)\theta c \right] n_y, \quad \frac{dV}{dn_x} = px - \bar{y} + (1-k)\theta cq - \omega(n_x). \tag{32}$$

Comparing market equilibrium to constrained and first best optima in (32) and (22) establishes

Proposition 2 *The market equilibrium is second-best, or constrained-efficient, as it maximizes welfare subject to the regulatory constraint. Compared to the first best, there are two distortions: insufficient liquidation of loans, $q < q^*$, and excess entry in the innovative sector, $n_x > n_x^*$. The distortions disappear if the equity premium is zero or the bank is fully equity funded.*

Proof. In market equilibrium, a bank's liquidation cut-off implied by the credit contract is given by (28) which implies $dV/dq = 0$. Similarly, using the free entry condition (30) to replace $\omega(n_x)$ in (32) also leads to $dV/dn_x = 0$. The noted distortions in the liquidation cut-off and entry decision relative to the first best allocation follow from a comparison of these conditions with (22); they only coincide if either $\theta = 0$ or $k = 1$. ■

In the presence of capital requirements, banks are too lenient and allow some firms in the downsizing sector to continue despite their rather poor perspectives. The reason is that banks must hold a capital buffer to absorb the write-off in the interim period, which is associated with additional capital costs. Therefore, it is optimal to liquidate less often and reduce credit reallocation, in order to economize on costs of equity. This behavior can be interpreted as some sort of 'Zombie' lending. In addition, there is excess entry in the innovative sector. The expected profit from entering the other sector, $\bar{\pi}_y = \bar{y}(q) - \bar{r} - (1-k)\,\theta cq$, falls more than proportionately as a result of inefficient liquidation and higher refinancing costs.[5] Intuitively, getting a second chance is less likely due to reduced credit reallocation such that more entrepreneurs enter the innovative sector despite of higher entry costs. These distortions are caused by the regulatory constraint combined with costly bank equity. If equity would earn the same return as debt, both credit reallocation and entry would be efficient.

3.2.3 Comparative Statics

We study the impact of four shocks - c insolvency law, θ equity premium, k capital requirement, and x return in the innovative sector - on the reallocation of credit, the initial and final sectoral allocation, banks' capital structure, and welfare. From $\bar{r} = r + \theta k$ in (26), and the solutions $pi_x = \bar{r}$ and $\pi_x = px - \bar{r}$, we get

$$d\bar{r} = k \cdot d\theta + \theta \cdot dk, \quad p \cdot di_x = d\bar{r}, \quad d\pi_x = p \cdot dx - k \cdot d\theta + \theta \cdot dk. \tag{33}$$

Turning to y-firms, we get the effect on liquidation from (28), giving

$$dq = -\frac{(1-k)\,c}{y} \cdot d\theta - \frac{px + (1-k)\,\theta}{y} \cdot dc + \frac{\theta c}{y} \cdot dk + \frac{p\,(1-c)}{y} \cdot dx. \tag{34}$$

Credit reallocation depends on bank and institutional characteristics. The share of reallocated credit falls with a higher equity premium and liquidation cost but it rises in the capital requirement and earnings in the x-sector (pull effect). A higher equity premium limits credit reallocation since holding a voluntary capital buffer is more expensive. A higher liquidation cost lowers the benefit from reallocation because it shrinks the released funds available for new lending to an x-firm. Tighter capital requirements relax the regulatory constraint. Recall that reallocation lowers both actual and required bank equity

[5] Profits in both sectors fall when equity is more costly due to capital requirements, leading to higher bank refinancing costs $\bar{r} > r$. Profits in the y sector, however, fall more strongly because the required capital buffer creates an extra cost $(1-k)\,\theta cq$ from reallocation. Liquidation and reallocation are inefficiently reduced, leading to smaller gains from entering the y-sector, compared to the first-best.

(the latter because the bank's assets, which need to be backed with equity, fall). If the regulatory capital ratio k is higher, the required bank equity shrinks relatively more with falling assets. The tighter regulatory stance thus eases the limits to reallocation.

Recall that due to bank competition, the credit contract maximizes expected profits in the y-sector: $\bar{\pi}_y = \max_q \bar{y} - \bar{r} - (1-k)\,\theta cq$. Using the Envelope theorem gives

$$d\bar{\pi}_y = -\left[k + (1-k)\,cq\right] \cdot d\theta - (1-cq)\theta \cdot dk + p(1-c)q \cdot dx - \left[px + (1-k)\theta\right] q \cdot dc. \quad (35)$$

Clearly, more expensive equity, a higher liquidation cost, and tighter capital requirements inflate costs and shrink the expected profit of a y-firm, whereas a higher return x boosts the value of a potential fresh start in the event of an insolvency.

The consequences for entry depend on how policy shocks affect expected sectoral profits. Noting $\omega' > 0$, the occupational choice condition (30) yields an unambiguous net effect equal to $\omega' \cdot dn_x = d\pi_x - d\bar{\pi}_y$ such that

$$dn_x = \frac{(1-k)\,cq}{\omega'} \cdot d\theta + \frac{\left[px + (1-k)\theta\right] q}{\omega'} \cdot dc - \frac{\theta cq}{\omega'} \cdot dk + \frac{p[1-(1-c)q]}{\omega'} \cdot dx. \quad (36)$$

Intuitively, the x-sector is less intensive in bank equity as no buffer for liquidation is required. Hence, expected profit shrinks relatively less when equity gets more costly which pushes firms into the x-sector. Similarly, higher liquidation costs make the possibility to get a second chance less likely. Entrepreneurs prefer to start an x-project right away even with somewhat higher entry costs, instead of acquiring experience in the y-sector and counting on a second chance upon liquidation. Tighter capital requirements, in turn, lower expected profits in both sectors due to higher loan rates of interest. However, they also reduce the size of the bank's capital buffer needed for y-firms. Hence, profits of y-firms shrink by less than that of x-firms. Eventually, a higher output x and, thus, a higher capital productivity attracts more entrepreneurs to the x-sector.

Sectoral expansion of the x-sector and downsizing of the y-sector refer to the *volume* of total investment which is driven both by initial entry and reallocation. Intuitively, the contribution of credit reallocation is substantial if banks aggressively liquidate poorly performing firms and the y-sector is large (high q and n_y). The output effect of reallocation is given by $n_x' - n_x = (1-c)\, qn_y$ and $n_y' - n_y = -qn_y$ such that expansion of the x-sector matches the downsizing of the y-sector net of liquidation costs, $n_x' - n_x = -(1-c)\left(n_y' - n_y\right)$. Differentiating yields $d\left(n_x' - n_x\right) = (1-c)\left[q \cdot dn_y + n_y \cdot dq\right] - qn_y \cdot dc$. Similarly, $d\left(n_y' - n_y\right) = -\left[q \cdot dn_y + n_y \cdot dq\right]$. Using the definitions $\eta \equiv q^2/\omega' + n_y/y > 0$ and $\hat{\eta} \equiv (1-c) \cdot \eta > 0$ and substituting solutions gives

$$\begin{aligned} d\left(n_x' - n_x\right) &= -(1-k)\, c\hat{\eta} \cdot d\theta - \left[\left(px + (1-k)\,\theta\right)\hat{\eta} + qn_y\right] \cdot dc \\ &\quad + \theta c\hat{\eta} \cdot dk - p\,(1-c)\left(q/\omega' - \hat{\eta}\right) \cdot dx, \qquad (37) \\ d\left(n_y' - n_y\right) &= (1-k)\, c\eta \cdot d\theta + \left[px + (1-k)\,\theta\right]\eta \cdot dc \\ &\quad - \theta c\eta \cdot dk + p\left(q/\omega' - \hat{\eta}\right) \cdot dx. \qquad (38) \end{aligned}$$

Credit reallocation magnifies the initial investment in the x-sector when banks' capital requirement increases, and when the equity premium and the liquidation cost fall. For example, a higher cost of equity inflates costs of the y-sector since it is relatively intensive in bank equity capital. In consequence, fewer start-ups enter the y-sector, and banks liquidate less often to economize on equity capital. For both reasons, the volume of credit reallocation to the x-sector falls. Higher liquidation costs have qualitatively the same effect. A higher return x, however, is associated with countervailing effects on liquidation and entry. It induces more aggressive loan liquidation but fewer entries into the downsizing sector leave less capital to be reallocated. Hence, the net effect on the volume of credit reallocation remains ambiguous.

Final investment changes by $dn_x' = dn_x + d\left(n_x' - n_x\right)$ and $dn_y' = dn_y + d\left(n_y' - n_y\right)$, or

$$\begin{aligned} dn_x' &= \left(q/\omega' - \hat{\eta}\right)\left[(1-k)\, c \cdot d\theta - \theta \cdot dk\right] + \left[\left(px + (1-k)\,\theta\right)\left(q/\omega' - \hat{\eta}\right) - qn_y\right] \cdot dc \\ &\quad + p\left[(1-c)^2 n_y/y + \left(1 - (1-c)\, q\right)^2/\omega'\right] \cdot dx, \qquad (39) \\ dn_y' &= -\left(q/\omega' - \eta\right)\left[(1-k)\, c \cdot d\theta - \theta \cdot dk + \left(px + (1-k)\,\theta\right) \cdot dc\right] \\ &\quad - p\left[(1-c)\, n_y/y + \left(1 - (1-c)\, q\right)(1-q)/\omega'\right] \cdot dx. \qquad (40) \end{aligned}$$

The effects on initial entry and on reallocation tend to offset each other. We can independently control the elasticity of first-time entry by making ω' large or small. If entry is extremely elastic ($\omega' \to 0$), then the sign of the final effect is given by the response of initial entry and the terms $q/\omega' - \eta$ and $q/\omega' - \hat{\eta}$ are positive. Consequently, a higher equity premium and liquidation cost boost the size of the innovative sector, whereas the reverse is true for tighter capital requirements. This scenario seems more likely as one might expect that reallocation weakens or reinforces the effects entry but cannot reverse it in sign. If entry is almost inelastic ($\omega' \to \infty$), however, the final change in sectoral output is dominated by the reallocation effect. Irrespective of the elasticity of entry, higher returns x always attract more capital to the innovative sector, and the positive entry effect prevails.

The effects on the capital structure of banks are driven by changes in the liquidation cut-off and entry. We focus on the initial capital ratio e since in the interim period, it is dictated by regulation.[6] The binding regulatory constraint yields $de = (1-k)\,c\,[n_y \cdot dq + q \cdot dn_y] + (1 - cqn_y) \cdot dk + (1-k)\,qn_y \cdot dc$, or upon substitution,

$$\begin{aligned} de &= -\left((1-k)\,c\right)^2 \eta \cdot d\theta + (1-k)\left[qn_y - (px + (1-k)\,\theta)\,c\eta\right] \cdot dc \\ &\quad + \left[(1-cqn_y) + (1-k)\,\theta c^2 \eta\right] \cdot dk - p\,(1-k)\,c\,(q/\omega' - \hat{\eta}) \cdot dx. \end{aligned} \tag{41}$$

When bank equity gets more expensive, equity intensive lending to the y-sector and loan liquidation are reduced in order to economize on using equity. Tighter capital requirements directly increases a bank's equity. In addition, higher standards induce more lending to the y-sector and more aggressive liquidation which further increases the equity buffer needed to satisfy the regulatory constraint. The responses to a higher liquidation cost and a higher return in the innovative sector are, in contrast ambiguous: Whenever liquidation entails a higher cost, banks ceteris paribus need to hold a higher equity buffer. At the same time, however, the volume of reallocated credit, which is proportional to the write-off, falls. Eventually, the ambiguous response to a higher return on innovative projects arises due to the countervailing entry and reallocation effects discussed earlier, and the capital ratio decreases in x unless more credit is liquidated.

[6] By construction, the capital ratio in the interim period equals $(e - cqn_y) / \left(n'_x + n'_y\right) = k$.

Aggregate welfare is given by (31). Since the market equilibrium is second-best, variations of entry and liquidation, dn_x and dq, have no significance for welfare which leaves the direct effects only:

$$dV = -e \cdot d\theta - [px + (1-k)\,\theta]\, qn_y \cdot dc - (1 - cqn_y)\,\theta \cdot dk + pn_x' \cdot dx. \tag{42}$$

Aggregate income $\Pi = pxn_x + \bar{y}n_y + rA$ is not directly affected by equity premium and capital requirements which merely redistribute profits from entrepreneurs to investors. The negative welfare effects arise because of the effort costs associated with equity. An increase in either the resource cost or the volume of equity creates a first-order welfare loss similar in kind to an increase in trade costs in international trade theory would do. Higher liquidation costs are also a welfare reducing resource cost. Eventually, a capital productivity x in the innovative sector boosts income and welfare. Summarizing the main findings establishes:

Proposition 3 *In the presence of a regulatory constraint,*

- *a higher equity premium θ reduces (share and volume of) credit reallocation, strengthens entry in the innovative sector, reduces the capital ratio of banks and lowers welfare;*
- *a tighter capital requirement k magnifies credit reallocation, discourages entry in the innovative sector, raises the capital ratio of banks but lowers welfare;*
- *a higher liquidation cost c slows down credit reallocation, shifts entry towards the innovative sector, lowers the capital ratio of banks and reduces welfare;*
- *a higher capital productivity x in the innovative sector increases the liquidation cut-off, boosts entry in the innovative sector, and increases welfare.*

Proof. Immediately follows from (34), (36-39), and (41-42). ■

Among the policy options to correct the main distortions caused by the banking sector - insufficient loan liquidation and excess entry in the innovative sector - are a lower equity premium and tighter capital requirements such that banks are better capitalized and can more easily absorb liquidation losses. The equity premium could be reduced, for example, by better investor protection and transparency that reduce investors' effort of supervision and management. It could also be reduced by eliminating the debt bias in corporate taxation by allowing a tax deduction for the cost of equity. Reforming insolvency laws could help banks to recover larger liquidation values and increase available funds for new lending which would boost credit reallocation and raise welfare.

4 Conclusions

An efficient financial sector promotes the process of creative destruction by withdrawing funds from declining firms and reallocating them to more productive ventures. The paper provides a first theoretical analysis of the process of credit reallocation and specifically focuses on the role of banks' capital structure. In our framework, banks liquidate loans when they receive bad news about poor prospects for success and full repayment. Liquidation releases locked up funds which banks can reallocate to new projects with better prospects. However, liquidation causes losses which impair their equity position and might lead to a violation of the regulatory constraint. Since recapitalization is especially difficult at a time of distress, banks need to build up a sufficient equity buffer a priori. Such a buffer is required to satisfy capital requirements in subsequent periods when the bank needs to absorb losses on non-performing loans.

The analysis identifies two main consequences of low equity. First, banks are hesitant to liquidate non-performing loans which blocks credit to profitable firms in the expanding sector and thereby slows down productivity growth. Since equity capital is more expensive than alternative sources of refinancing, banks economize on the use of equity. In consequence, capital buffers tend to be tight which later on interfers with the ability of banks to more aggressively liquidate unprofitable firms and reallocate credit to more productive uses. Second, reduced credit reallocation distorts start-up investment across sectors. If the alternative route of entering the traditional sector, accumulating business experience and trying later on a fresh-start in the innovative sector is blocked, too many firms incur the higher start-up costs of entering the innovative sector right from the beginning. Governments can alleviate these frictions and ease the process of creative destruction in several ways. They could aim at making equity capital more available and less expensive by abolishing tax distortions and improving the standards of investor protection. They could tighten minimum capital requirements to boost the ability of banks to absorb losses from liquidation or restructuring. They could also reform insolvency laws to lower liquidation costs and facilitate fresh starts.

Appendix

This section collects the assumptions that are necessary for an (interior) solution. The benchmark model requires

$$y > px(1-c) \quad \Leftrightarrow \quad q < 1, \tag{A.1}$$

$$2px - y - \frac{[px(1-c)]^2}{y} > 0 \quad \Leftrightarrow \quad \omega(n_x) = \pi_x - \bar{\pi}_y > 0. \tag{A.2}$$

If entrepreneurs have an outside option, their (maximum) profits need to be nonnegative. Since $\pi_x > \bar{\pi}_y$, it is sufficient to assume

$$y + \frac{[px(1-c)]^2}{y} - 2r > 0. \tag{A.3}$$

The constrained model also requires

$$\frac{px}{px + \theta(1-k)} > c \quad \Leftrightarrow \quad q > 0, \tag{A.4}$$

$$y + \frac{[px(1-c) - \theta c(1-k)]^2}{y} - 2\bar{r} > 0 \quad \Leftrightarrow \quad \bar{\pi}_y > 0. \tag{A.5}$$

Recall that the profit differential $\pi_x - \bar{\pi}_y$ is larger in the constrained model such that it is necessarily positive whenever assumption (A.2) holds.

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