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Portfolio effects and efficiency of lending under Basel II

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The views expressed are those of the author and do not necessarily reflect the views of the Bank of Finland.

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Abstract

Although beneficial allocational effects have been a central motivation for the Basel II capital adequacy reform, the interaction of these effects with Basel II's procyclical impact has been less discussed. In this paper, we investigate the effect of Basel II on the efficiency of bank lending. We consider competitive credit markets where entrepreneurs may apply for loans for investments of different risk profiles. In this setting, excessive risk taking typically arises because low risk borrowers cross-subsidize high risk borrowers through the price system that is based on average success rates. We find that while flat-rate capital requirements (such as Basel I) amplify overinvestment in risky projects, risk-based capital requirements alleviate the cross-subsidization effect, improving allocational efficiency. This also suggests that Basel II does not necessarily lead to exacerbation of macroeconomic cycles because the reduction in the proportion of high-risk investments softens the cyclicality of bank lending over the business cycle.

Key words: Basel II, bank regulation, capital requirements, credit risk, procyclicality

JEL classification numbers: D41, D82, G14, G21, G28

Basel II -vakavaraisuussääntelyn vaikutukset pankkiluottojen optimaaliseen kohdentumiseen

Suomen Pankin keskustelualoitteita 13/2007

Esa Jokivuolle – Timo Vesala
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Pankkien vakavaraisuussääntelyn uudistuksessa (Basel II) on keskeisenä tavoitteena se, että sääntely tehostaisi pankkiluottojen kohdentumista. Toisaalta uusien vakavaraisuusvaatimusten pelätään vahvistavan suhdanteita. Näiden asioiden yhteisvaikutuksesta ei ole kuitenkaan juuri keskusteltu. Tässä tutkimuksessa tarkastellaan Basel II:n vaikutusta luottojen optimaaliseen kohdentumiseen. Kilpailullisessa luottomarkkinamallissa yrittäjät voivat hakea luottoa projekteille, joilla on erilainen riski. Tämä johtaa liian suuriin riskipitoisiin investointeihin, koska luotonottajista alhaisen riskin ottavat kompensoivat suuren riskin ottavia sellaisen hintamekanismin kautta, joka perustuu todennäköisyyteen, miten yrittäjät onnistuvat keskimäärin. Tulokseksi saadaan, että kiinteä vakavaraisuusvaatimus voimistaa liiallisen investoinnin ongelmaa. Basel II:n kaltainen riskiperusteinen vakavaraisuusvaatimus sen sijaan lieventää ristisubventiota ja tehostaa siten luottojen kohdentumista. Tulokset viittaavat myös siihen, että Basel II -sääntely ei välttämättä voimista suhdanteita, koska riskipitoisimpien investointien suhteellisen osuuden pieneneminen voi vähentää pankkien luotonannon suhdanneherkkyyttä.

Avainsanat: Basel II, pankkisääntely, vakavaraisuusvaatimukset, luottoriski, myötäsyklisyys

JEL-luokittelu: D41, D82, G14, G21, G28

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1 Introduction

The Basel II Accord introduces an important refinement to bank regulation practice as it proposes new, internal-ratings-based (IRB) capital requirements. IRB means that the amount of capital a bank will need to hold against a given asset will explicitly depend on the credit risk of that asset.[1] Under the previous regulatory framework (Basel I), banks faced a fixed 8% minimum capital requirement against any risky asset in their corporate loan portfolio. The 'flat-rate' capital requirement thus worked as a buffer against average credit risks. As the cost of holding capital comes over to loan prices, the flat-rate requirement effectively means that low risk customers cross-subsidize high risk borrowers which increases the attractiveness of high risk loans and thus raises the average credit risk in a bank's loan portfolio. An obvious advantage of the Basel II reform is that it alleviates these potential allocational distortions across different loan categories (see also the motivation provided for Basel II by the Basel Committee, 2001). At the same time, however, it has been argued that a potentially serious drawback of the reform is that the IRB practice may fuel 'procyclicality' (see eg Kashyap and Stein, 2004, Gordy and Howells, 2006, Pennacchi, 2005, provides a discussion of this literature). In a downturn, when credit losses erode banks' capital base, the default probability of the surviving customers increases, implying that banks must hold more capital against their portfolios. Since raising new capital during bad times may be difficult or very costly, banks may be forced to scale back their lending activity, thereby exacerbating the recession.

Although the beneficial allocational effects have been a central motivation for the Basel II reform, their interaction with Basel II's procyclical impact has been discussed only a little. Namely, the seriousness of the procyclicality issue could depend on the risk-profile of banks' loan portfolios. If the relative share of risky assets is high, then the need to collect fresh capital after a negative shock may be significant due to large credit losses and the substantial increase in the default probability of the remaining borrowers.[2] However, since IRB unravels the cross-subsidization mechanism related to the flat-rate regime, one could think that IRB induces a general shift towards less risky portfolios. The relevance of the procyclicality issue may thus depend on the magnitude of this portfolio effect, as it alleviates the potential squeeze in an economic downturn due to higher capital requirements and credit losses. Moreover,

[1] More precisely, the bank is using a scale of internal ratings in which each credit customer is categorized. The bank further estimates the average probability of default in each rating category, which, along with other credit risk parameters, determines the minimum capital requirement (for the details see Basel Committee on Banking Supervision, 2006). Throughout this paper it is implicitly assumed that there is no moral hazard in banks' determining the internal ratings and hence their own capital requirement. The consequences of relaxing this assumption are studied eg in Blum (2007).

[2] It has been argued (see eg Peura and Jokivuolle, 2004) that banks can hold extra buffers of capital in excess of the minimum capital requirement and thereby alleviate procyclical effects. Zicchino (2006) considers a bank which sets its capital level as part of its value maximizing behaviour and finds that under Basel II lending is likely to be, nevertheless, more responsive to macroeconomic shocks than under Basel I. An interesting related analysis is also provided by Zhu (2007).

this counterbalancing effect may be coupled with a more efficient allocation of lending obtained with the IRB regime.[3]

In this paper, we construct a model where 'entrepreneurs' can choose between investments of different risk characteristics (as in Vesala, 2007), or they can decide not to take up a risky investment at all. More specifically, we consider two uncertain investment opportunities, an 'high-risk' and a 'low-risk' investment, and also an outside option that produces a fixed payoff with certainty. Following De Meza and Webb (1987), entrepreneurs' intrinsic and unobservable 'types' determine their success rates in risky investments. High-risk projects are more sensitive to entrepreneurs' types than low-risk investments while the payoff of the outside option is independent of the intrinsic type. Efficient resource allocation requires that entrepreneurs with the highest types invest in high-risk projects, which also offer the best payoff when successful, while entrepreneurs at the bottom end of the type distribution do not invest at all but stick to the safe outside option. Types located in the middle should invest in low-risk projects. Banks cannot observe the explicit success rate of an individual entrepreneur but they rationally expect the equilibrium average success probabilities within each investment class. Banks operate in competitive credit markets where loan prices for high-risk and low-risk investments are determined by banks' posterior beliefs about average success rates within each investment category. The competitive loan prices, in turn, govern entrepreneurs' self-selection among different investment opportunities. Note that we do not consider capital markets as an alternative source of finance for the entrepreneurs. The entrepreneurs in the model could perhaps best be understood as representing the small and medium size corporate portfolio of banks. Therefore informational problems could be alluded to as the reason why these entrepreneurs go to banks for finance.

Our objective is to investigate the efficiency of resource allocation in the credit market under the flat-rate and the risk-based capital requirements. The conventional result in this kind of setting is that there is too much risk-taking because low risk borrowers cross-subsidize high risk borrowers through the price system that is based on average success rates (De Meza and Webb, 1987).[4] We find that the flat-rate regime exacerbates this problem and it allocates too much investment in high-risk projects. We also observe that the flat-rate capital requirements induce a trade-off between optimal composition of loans and the efficiency of overall bank lending volume. Compared to the flat-rate regime, the risk-based capital requirements alleviate the cross-subsidization effect in high-risk investments and thereby reduce overinvestment in these

[3]There are also studies which investigate how Basel II regulation could be improved to reduce the procyclical effects. Kashyap and Stein (2004) and Gordy and Howells (2006) suggest and consider time-varying capital requirements. However, Pennacchi (2005) argues these studies do not take into account implications for deposit insurance losses and suggests instead integration of risk-based deposit insurance with risk-based capital requirements to reduce the procyclical impact.

[4]Overinvestment in high-risk assets, the central starting point of our analysis, is also consistent with the view that risks may build up during economic upturns (see eg Borio et al., 2001, and Rajan, 1994). Because the role of regulatory capital requirements is accentuated particularly in such circumstances, we believe that the overinvestment problem is an important setting to study the effects of Basel II.

projects. On the other hand, lower capital requirement against low-risk loans increases entrepreneurs' general participation in the credit market, so that the overall lending volume is higher under the risk-based capital requirements than under the flat-rate regime. It is also shown that there exists a risk-based capital requirement schedule that implements both the first-best loan composition and the first-best lending volume.

Finally, we also assess the magnitude of the 'portfolio effect' resulting from the change in the regulatory framework and argue that the effect can be substantial. This is because under the flat-rate regime the average quality of high-risk loans is decreasing with the fixed capital requirement. In a long-run equilibrium, poorer average loan quality requires higher capital holdings to compensate the increased loss potential, which further deteriorates the average success rate of high-risk investments. Under the risk-based capital regulation, however, this vicious circle does not emerge but higher regulatory capital only improves the average quality of high-risk loans. Therefore the new equilibrium with risk-based capital requirements may feature (potentially) a much more efficient resource allocation. Moreover, reminiscent of Repullo (2004), a strong portfolio effect also implies that the introduction of risk-based capital requirements would allow for a reduction in the overall level of regulatory capital.[5] Hence, regarding the discussion about Basel II and the procyclicality of bank lending, our findings suggest that Basel II does not necessarily lead to exacerbation of macroeconomic cycles (cf. Gordy and Howells, 2006).[6] At the least, the allocational effects should be taken into account in assessing the overall procyclical impact of a capital adequacy regime.

So far, there are only a handful of papers focusing on the portfolio effect. Maybe the closest study to ours is Repullo and Suarez (2004) which investigates the loan pricing implications of Basel II capital requirements. They consider both the 'standardized' approach based on external ratings as well as the IRB approach.[7] In their model, banks can differentiate by choosing either the standardized approach or the IRB. Repullo and Suarez conclude that low risk borrowers achieve reductions in loan rates as they do business with banks using IRB. However, the prospects of high-risk borrowers may not be weakened as they may borrow from banks adopting the standardized approach. Other related studies mainly focus on the procyclicality issue without long-term portfolio effects (eg Kashyap and Stein, 2004),[8] the justifications of 'excess' capital buffers (Allen, Carletti and Marquez, 2005), or empirical evidence about the cyclical fluctuations of these buffers (Ayuso, Pérez and Saurina,

[5] Interestingly, this is not stated to be the objective of Basel II. According to the Basel Committee (2001), the goal of Basel II is 'neither to produce a net increase nor a net reduction – on average – in minimum regulatory capital'.

[6] Also the Basel Committee (2001) has pointed out that '(Basel I) which does not adequately reflect changes in risk creates incentives for banks to make high-risk investments that may contribute to cyclicality over the business cycle'.

[7] In Basel II banks have the option to use either the simpler and less risk-sensitive standardized approach or the more sophisticated and risk-sensitive IRB approach, subject to supervisory approval. In practice it is expected that large and sophisticated banks opt for the latter. In the US, the largest banks will only have the choice of the IRB approach.

[8] An exception is, however, Gordy and Howells (2006) who consider procyclical effects in a simulation based approach including active portfolio management.

2003, Jokipii and Milne, 2007). Lastly, we refer to the paper by Repullo (2004) where the role of capital requirements in preventing 'gambling' in bank lending is stressed. He finds that both the flat-rate and the risk-based capital regime can be successful in this objective, albeit under the risk-based system the prevention of gambling is implemented with lower overall level of regulatory capital. Our results suggest, however, that flat-rate capital requirements may actually increase 'gampling' (in the sense of overinvestment in the riskiest projects by the entrepreneurs) whereas moving from flat-rate capital requirements to the risk-based system may significantly reduce 'gambling' as overinvestment in the riskiest projects is reduced.

The paper is organized as follows. Section 2 prescribes the general modelling environment, and section 3 presents equilibrium analysis. Implications on the procyclicality debate are discussed in Section 4. Section 5 concludes.

2 The model

Entrepreneurs have access to either an 'high-risk' or a 'low-risk' investment. When successful, a high-risk project produces v while the output of a low-risk investment is of worth $s < v$. If a project fails it produces nothing, regardless of the type of the investment. Entrepreneurs differ in their 'intrinsic types'. The type parameter θ is distributed over $\Theta = [0, 1]$ according to a strictly increasing function $G(\theta)$. $G(\theta)$ is common knowledge but the actual realization of θ is entrepreneur's private information. The success probability of an investment depends on entrepreneur's type θ. The type dependent success rates of a high-risk and a low-risk investment are denoted by $p(\theta)$ and $q(\theta)$ respectively, so that the expected outputs are $p(\theta)v$ and $q(\theta)s$. We assume

$$p'(\theta) > q'(\theta) > 0, \forall \theta \in \Theta. \tag{2.1}$$

Hence, while both success rates are strictly increasing in θ, a high-risk investment is riskier than a low-risk one as it is more sensitive to entrepreneur's intrinsic type.

Instead of making an investment, entrepreneurs may also choose an outside option (eg participation in the labor market) which produces an exogenously given payoff w. The magnitude of this fixed payoff is independent of θ. Moreover, we assume

$$p(1)v > q(1)s > w \text{ but } p(0)v < q(0)s < w, \tag{2.2}$$

ie, a high-risk investment has the greatest expected output for entrepreneurs at the upper end of the type distribution while entrepreneurs at the bottom end of the distribution should choose the outside option.

The implementation of any new investment requires external finance equal to a constant amount, I. These external resources can be obtained from competitive credit markets where banks deliver standard debt contracts. If I units of financial capital were invested elsewhere in the financial markets, banks could earn $\bar{R}$. $\bar{R}$ thus serves as the opportunity cost of finance. Moreover, the

regulator requires the banks to raise equity capital K. Under the flat rate regime, the requirement is to hold at least a minimum capital $K = \bar{k}$ per unit of loans, regardless of the risk status of the asset. Under the risk-based regime, however, the requirement is to hold $K = k_v$ per unit of high-risk loans and $K = k_s$ per unit of low-risk loans.

The timing of events is as follows:[9]

Stage 1

Nature draws entrepreneurs' types from the distribution $G(\theta)$ with support $\Theta = [0, 1]$.

Stage 2

Entrepreneurs choose whether to invest in an uncertain project or stick to the safe outside option. If they choose to invest, they need external finance in order to implement the project. Before entering the credit market, entrepreneurs have to fix the business plan for which they are seeking finance. Banks can observe whether the chosen project is high-risk or low-risk, and they are able to monitor the implementation of the chosen project.

Stage 3

Entrepreneurs and banks trade in a competitive credit market. Upon a trading opportunity, loan contracts can only be conditioned on the observable project characteristics but not on the unobservable entrepreneur type.

Stage 4

Outputs are realized. If the project has been successful, the bank receives the repayment and the entrepreneur keeps the residual. A failure incurs a credit loss to the bank.

From assumptions (2.1) and (2.2) it follows that there are two unique cut-offs $\overline{\theta}^{fb}$ and $\underline{\theta}^{fb}$ s.t.

$$p(\overline{\theta}^{fb})v = q(\overline{\theta}^{fb})s \text{ and } q(\underline{\theta}^{fb})s - \bar{R} = w. \tag{2.3}$$

The upper index in these thresholds stands for 'first-best' as efficient resource allocation is obtained when types $\theta \in [\overline{\theta}^{fb}, 1]$ choose high-risk investments, types $\theta \in [\underline{\theta}^{fb}, \overline{\theta}^{fb})$ stick to low-risk projects and types $\theta \in [0, \underline{\theta}^{fb})$ choose the fixed outside option.

In the market solution, the marginal type that is indifferent between a high-risk and a low-risk investment is denoted by $\overline{\theta}$. Since any type above this cut-off has a greater success probability (and thereby greater expected payoff) in a high-risk project than the type $\overline{\theta}$, it must hold that types $\theta > \overline{\theta}$ strictly prefer high-risk investments over low-risk ones. Correspondingly, types $\theta < \overline{\theta}$ strictly prefer low-risk projects over high-risk investments. As an application

[9] The sequence of events adopted here draws on the model by Vesala (2007).

of Bayes' rule, the expected success probability of an entrepreneur with a high-risk investment is given by

$$p(\hat{\theta}_v) = \frac{\int_{\overline{\theta}}^{1} p(\theta) dG(\theta)}{1 - G(\overline{\theta})}. \tag{2.4}$$

Similarly, the type that is indifferent between a low-risk investment and the outside option is denoted by $\underline{\theta}$. Again we must have that types $\underline{\theta} < \theta < \overline{\theta}$ strictly prefer a low-risk investment and types $\theta < \underline{\theta}$ strictly prefer choosing the fixed payoff. The expected success probability of an entrepreneur with a low-risk investment is thus given by

$$q(\hat{\theta}_s) = \frac{\int_{\underline{\theta}}^{\overline{\theta}} q(\theta) dG(\theta)}{G(\overline{\theta}) - G(\underline{\theta})}. \tag{2.5}$$

In competitive credit markets, banks make on average zero profits in their lending business. In other words, the expected repayment just covers the opportunity cost of finance $\bar{R}$ plus the value of the regulatory equity capital K; ie, $p(\hat{\theta}_v)R_v = \bar{R} + K$ and $q(\hat{\theta}_s)R_s = \bar{R} + K$ where R_v and R_s denote the competitive loan rates for high-risk and low-risk investments respectively. Solving for R_v and R_s yields

$$R_v = \frac{\bar{R} + K}{p(\hat{\theta}_v)} \text{ and } R_s = \frac{\bar{R} + K}{q(\hat{\theta}_s)}.$$

Entrepreneurial payoffs from high-risk and low-risk investments are given by

$$\pi_v(\theta, \hat{\theta}_v) = p(\theta)(v - R_v) = p(\theta)v - \frac{p(\theta)}{p(\hat{\theta}_v)}(\bar{R} + K), \tag{2.6}$$

$$\pi_s(\theta, \hat{\theta}_s) = q(\theta)(s - R_s) = q(\theta)s - \frac{q(\theta)}{q(\hat{\theta}_s)}(\bar{R} + K). \tag{2.7}$$

3 Equilibrium analysis

Entrepreneurs choose their projects by comparing the expected payoffs from high-risk and low-risk investments, and from the fixed outside option. The marginal type $\overline{\theta}$ is indifferent between the two investment options and $\underline{\theta}$ between a low-risk investment and the safe payoff. Banks, who observe entrepreneurs' investment choices but not their explicit types, use the Bayes' rules in (2.4) and (2.5) to update their posterior beliefs about the average success probabilities of a high-risk and a low-risk investment. As a formal definition, we have:

Definition 3.1 *A perfect Bayesian equilibrium specifies a quadruple* $(\overline{\theta}^*, \underline{\theta}^*, \hat{\theta}_v^*, \hat{\theta}_s^*)$ *which is a solution to the following system of equations:*

$$(i)\ \pi_v\left(\overline{\theta}^*, \hat{\theta}_v^*\right) = \pi_s\left(\overline{\theta}^*, \hat{\theta}_s^*\right),$$

$$(ii)\ \pi_s\left(\underline{\theta}^*, \hat{\theta}_s^*\right) = w,$$

$$(iii)\ p(\hat{\theta}_v^*) = \int_{\overline{\theta}^*}^{1} p(\theta) dG(\theta) / [1 - G(\overline{\theta}^*)],$$

$$(iv)\ q(\hat{\theta}_s^*) = \int_{\underline{\theta}^*}^{\overline{\theta}^*} q(\theta) dG(\theta) / [G(\overline{\theta}^*) - G(\underline{\theta}^*)].$$

3.1 Flat-rate capital requirements

Under flat-rate capital requirements, $K = \bar{k}$ regardless of the type of the investment. First, the equilibrium condition (i) implies:

$$\begin{aligned} p(\overline{\theta}^{FR})v - \frac{p(\overline{\theta}^{FR})}{p(\hat{\theta}_v^{FR})}(\bar{R}+\bar{k}) &= q(\overline{\theta}^{FR})s - \frac{q(\overline{\theta}^{FR})}{q(\hat{\theta}_s^{FR})}(\bar{R}+\bar{k}) \Leftrightarrow \\ p(\overline{\theta}^{FR})v - q(\overline{\theta}^{FR})s &= (\frac{p(\overline{\theta}^{FR})}{p(\hat{\theta}_v^{FR})} - \frac{q(\overline{\theta}^{FR})}{q(\hat{\theta}_s^{FR})})(\bar{R}+\bar{k}), \end{aligned} \tag{3.1}$$

where $\overline{\theta}^{FR}$ and $\hat{\theta}_v^{FR}$ denote the equilibrium values of $\overline{\theta}$ and $\hat{\theta}_v$ under the flat-rate regime.

Proposition 3.2 *Given the flat-rate capital requirements, there is overinvestment in high-risk projects as entrepreneurs with inefficiently low success rates choose this investment opportunity; ie,* $\overline{\theta}^{FR} < \overline{\theta}^{fb}$ *and* $\hat{\theta}_v^{FR} < \hat{\theta}_v^{fb}$.

Proof: Follows from the observation that the RHS of (3.1) is strictly negative, which directly implies that $\overline{\theta}^{FR} < \overline{\theta}^{fb}$ and thereby $\hat{\theta}_v^{FR} < \hat{\theta}_v^{fb}$.■

By equation (3.1) it is obvious that the overinvestment problem would exist also without any extra capital requirement, ie, when $\bar{k} = 0$. This is the conventional DeMeza-Webb (1987) overinvestment result and it stems from the effect that the high types investing in high-risk projects cross-subsidize the low types investing in similar projects through the price system that is based on average success rates. A flat-rate capital requirement, which indiscriminately comes over to all loan prices regardless of the average risk level of the loan, amplifies overinvestment in high-risk projects because the marginal type becomes cross-subsidized for this extra cost in the market for high-risk loans while in the category of low-risk loans she would be the one who would cross-subsidize entrepreneurs with lower success rates. Hence, the higher is the flat-rate requirement $\bar{k}$ the greater is the distortion towards high-risk investments.

Second, from the equilibrium condition (ii) it follows that

$$q(\underline{\theta}^{FR})s - \bar{R} - w = \frac{q(\underline{\theta}^{FR})}{q(\hat{\theta}_s^{FR})}\bar{k} - \frac{q(\hat{\theta}_s^{FR}) - q(\underline{\theta}^{FR})}{q(\hat{\theta}_s^{FR})}\bar{R}. \tag{3.2}$$

Remark 3.3 *The cut-off* $\underline{\theta}^{FR}$*, which determines the division of entrepreneurs between investment and the safe outside option, is efficient if the flat-rate capital requirement satisfies*

$$\bar{k} = (\frac{q(\hat{\theta}_s^{fb})}{q(\underline{\theta}^{fb})} - 1)\bar{R} \equiv \bar{k}^{fb}.$$

If $\bar{k} < \bar{k}^{fb}$ *entrepreneurs with inefficiently low success rates choose to invest in low-risk projects. On the other hand, if* $\bar{k} > \bar{k}^{fb}$*, too many entrepreneurs opt to choose the fixed payoff.*

Proof: Follows directly from (2.3) and (3.2) .■

Since the extra capital requirement does not hit the payoff from the fixed outside option, $\bar{k}$ can be used to limit market participation. At the margin where entrepreneurs are indifferent between taking up a low-risk investment and opting the safe payoff the capital requirement reduces the incentive to invest and thus alleviates the excess market entry due to the cross-subsidization effect. $\bar{k}^{fb}$ is exactly the level of regulatory capital that implements the first-best division. If the capital requirement is greater than this, there will be underinvestment. Also observe that as the distortion in the high-risk investment margin is minimized when $\bar{k} = 0$ the introduction of a flat-rate capital adequacy regime necessarily induces a trade-off between optimal composition of loans and the efficiency of the overall bank lending volume. Obviously, the flat-rate capital requirement which minimizes the overall distortions is somewhere in between 0 and $\bar{k}^{fb}$; ie there will be both overinvestment in expansionay projects and excess market entry by entrepreneurs.

3.2 Risk-based capital requirements

Under the risk-based capital requirements, $K = k_v$ for high-risk investments and $K = k_s$ for low-risk investments. The equilibrium condition (i) then implies

$$p(\overline{\theta}^{RB})v - q(\overline{\theta}^{RB})s = (\frac{p(\overline{\theta}^{RB})}{p(\hat{\theta}_v^{RB})} - \frac{q(\overline{\theta}^{RB})}{q(\hat{\theta}_s^{RB})})(\bar{R} + k_s) + \frac{p(\overline{\theta}^{RB})}{p(\hat{\theta}_v^{RB})}(k_v - k_s) \quad (3.3)$$

Similarly, the condition (ii) now reads as

$$q(\underline{\theta}^{RB})s - \bar{R} - w = \frac{q(\underline{\theta}^{RB})}{q(\hat{\theta}_s^{RB})}k_s - \frac{q(\hat{\theta}_s^{RB}) - q(\underline{\theta}^{RB})}{q(\hat{\theta}_s^{RB})}\bar{R}. \quad (3.4)$$

Remark 3.4 *The cut-offs $\overline{\theta}^{RB}$ and $\underline{\theta}^{RB}$ are efficient, if*

$$\begin{aligned} k_s &= (\frac{q(\hat{\theta}_s^{fb})}{q(\underline{\theta}^{fb})} - 1)\bar{R} \equiv k_s^{fb} \\ k_v &= (\frac{p(\hat{\theta}_v^{fb})}{p(\overline{\theta}^{fb})}\frac{q(\overline{\theta}^{fb})}{q(\underline{\theta}^{fb})} - 1)\bar{R} \equiv k_v^{fb} \end{aligned}$$

Proof: Follows directly from (2.3), (3.3) and (11).■

Remark 3.4 states that, contrary to the flat-rate regime, there exists a risk-based capital requirement schedule that implements both the first-best loan composition and the first-best lending volume. This is quite natural, of course, as the risk-based system offers as many independent instruments to affect allocational efficiency as there are different loan categories. This

is not the case under the fixed capital requirement where there is only one instrument and efficiency can be obtained only at the margin where entrepreneurs are indifferent between investment and the safe outside option. Since the indifference condition between a low-risk investment and the safe outside option is essentially the same under both regimes, the efficient overall lending volume is implemented when the risk-based capital requirement for low-risk investments coincide with the flat-rate requirement given in Remark 3.3; ie, $\bar{k}^{fb} = k_s^{fb}$. In turn, as $p(\hat{\theta}_v^{fb}) > p(\overline{\theta}^{fb})$ and $q(\overline{\theta}^{fb}) > q(\hat{\theta}_s^{fb})$, the risk-based capital requirement against high-risk investments that implements the efficient loan composition must be strictly greater than the capital requirement against low-risk loans; ie, it must hold that $k_v^{fb} > k_s^{fb} = \bar{k}^{fb}$.

In practice, fostering allocational efficiency is hardly the only – nor even the most important – objective of bank capital regulation. The primary goal of a regulator is to ensure that the capital holdings suffice to cover the potential credit losses incurred in the case when the economy is hit by an unexpected negative shock.[10] Here we assume that such a negative shock causes a downward shift in the success probability functions $p(\theta)$ and $q(\theta)$, and tha t the shock has greater impact on prospects of high-risk investments. Hence, the amount of credit losses incurred by the shock are decreasing in the average success rates $p(\hat{\theta}_v)$ and $q(\hat{\theta}_s)$, and it should hold for the required capital holdings that $k_v(\hat{\theta}_v) > k_s(\hat{\theta}_s)$. What we are still missing is the linkage between these risk-based capital requirements and the flat-rate measure $\bar{k}$. In a long run equilibrium, it is plausible to assume that the relationship between the flat-rate and the risk-based capital requirement is such that the flat-rate requirement is roughly equal to a 'weighted average' of the hypothetical risk-based schedule with the given equilibrium loan composition; ie,

$$\bar{k} \approx \frac{[1 - G(\overline{\theta}^{FR})]k_v(\hat{\theta}_v) + [G(\overline{\theta}^{FR}) - G(\underline{\theta}^{FR})]k_s(\hat{\theta}_s)}{1 - G(\underline{\theta}^{FR})}. \tag{3.5}$$

As an immediate consequence of this we have $k_s(\hat{\theta}_s) < \bar{k} < k_v(\hat{\theta}_v)$, and

Proposition 3.5 *Given that $k_s(\hat{\theta}_s) < \bar{k} < k_v(\hat{\theta}_v)$, it holds that*

$$\overline{\theta}^{RB} \geq \overline{\theta}^{FR} \text{ and } \underline{\theta}^{RB} < \underline{\theta}^{FR}.$$

Hence, there is less investment in high-risk projects under the risk-based capital requirements than under the flat-rate capital requirements but the overall lending volume under the risk-based regime is greater than under the flat-rate regime.

Proof: Follows from the observations that the RHS of equation (3.3) is strictly larger than the RHS of equation (3.1) , while the RHS of equation (3.4) is strictly smaller than that of equation (3.2).■

Compared to the flat-rate regime, the risk-based capital adequacy regime alleviates overinvestment in high-risk projects because it counterbalances the

[10] Ie a shock that entails a realization of risks which are not fully internalized in the competitive loan prices.

cross-subsidization effect at the margin where entrepreneurs are indifferent between high-risk and low-risk projects. On the other hand, lower capital requirement against low-risk loans increases entrepreneurs' participation to the credit market, so that the overall lending volume is higher under the risk-based system than under the flat-rate regime. Moreover, from equation (3.5) and Proposition 3.5 it follows that the average capital holding against a risky asset, ie either a low-risk or a high-risk loan, is larger under the flat-rate regime than under the risk-based system because the allocation of financial resources is less efficient with the flat-rate requirements.

We have now demonstrated the presumable effect of Basel II on the composition of banks' loan portfolios. However, it is also important to try to assess the magnitude of this effect. Figure 1 illustrates how the equilibrium volume of investment in high-risk projects changes when risk-based capital requirements replace the old flat-rate system. The vertical axis represents the average success probability in high-risk investments. The average success rate is at the highest when only the very top end of the type distribution invests in high-risk projects (ie, when $\overline{\theta} \to 1$ so that $p(\hat{\theta}_v) \to p(\hat{\theta}_v^1)$). In this extreme case, both $\bar{k}$ and $k_v(\hat{\theta}_v^{RB})$ approach to $k_s(\hat{\theta}_s^1)$ as only low-risk investments are undertaken. $k_s(\hat{\theta}_s^1)$ is the equilibrium regulatory capital in this scenario. On the other hand, when $\overline{\theta} \to 0$ (and hence $p(\hat{\theta}_v) \to p(\hat{\theta}_v^0)$) all entrepreneurs invest in high-risk projects and the two alternative capital regulation systems virtually coincide. Generally, however, $\bar{k} < k_v(\hat{\theta}_v^{RB})$ because $\bar{k}$ is levied also on low-risk projects so that the burden to hold capital against high-risk investments is lower. The main insight in Figure 1 is that the change from the flat-rate capital requirements to the risk-based capital regulation may have a substantial effect on banks' loan portfolio (measured by the vertical axis in Figure 1). This is because under the flat-rate regime the equilibrium cut-off $\overline{\theta}^{FR}$, which also determines the average success probability $p(\hat{\theta}_v^{FR})$, is decreasing in the fixed capital requirement $\bar{k}$ while under the risk-based regulation the cut-off $\overline{\theta}^{RB}$ (and thus $p(\hat{\theta}_v^{RB})$) is increasing in k_v. Hence, under the flat-rate regime, higher capital requirements worsen the average quality of high-risk loans, which again requires higher capital holdings to compensate the increased loss potential. Under the risk-based capital regulation, however, such a trade-off between the level of capital requirement and the efficiency of entrepreneurial selection does not emerge but higher regulatory capital improves the average quality of high-risk loans. The new equilibrium may therefore feature a much more efficient resource allocation. Also the overall level of regulatory capital may be significantly reduced. It should be emphasised, however, that Figure 1 merely illustrates the potential consequence of the Basel II changeover; it is not suitable for a conclusive assessment of the quantitative significance of the portfolio effect.

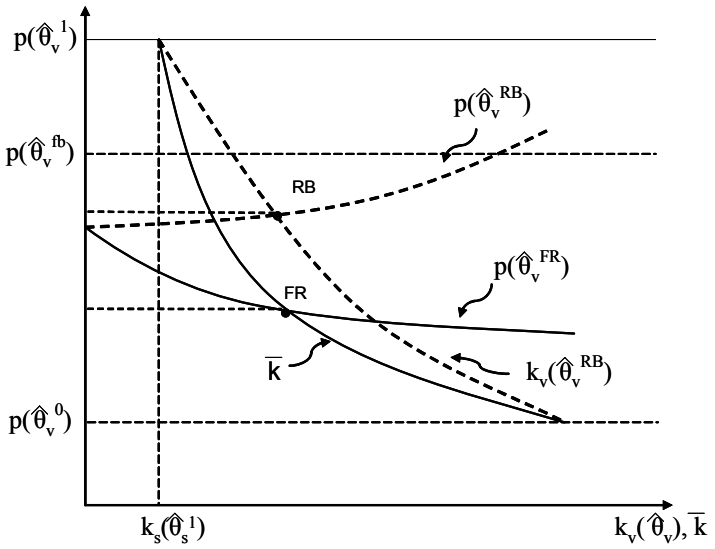

Figure 1: Equilibria under flat-rate and risk-based capital requirements

4 Implications on procyclicality

Since the allocational effect analysed in this paper potentially has a bearing on the vulnerability of the economy to shocks, it should be taken into account in assessing the overall propensity of a capital adequacy regime to procyclicality. The alleged procyclical impact of the Basel II may turn out to be less pronounced if the reduced proportion of high-risk investments softens the cyclicality of bank lending over the business cycle. This argument is in line with the view of Gordy and Howells (2006) who also note that the endogenous response by banks to Basel II does not necessarily lead to exacerbation of macroeconomic cycles. In this section we provide a discussion of the implications of our previous analysis on procyclicality under Basel I flat-rate capital requirements versus Basel II risk-based capital requirements. The argumentation is heuristic in nature but makes use of the results of our analytical model.

Let us first assume that the overall amount of lending is efficient under both Basel I and Basel II capital requirement regimes. Under Basel I there is overinvestment in high-risk projects whereas under Basel II the efficient allocation between high-risk and low-risk projects can be implemented. Now consider a negative shock to the economy in the current period, which leads to a materialization of loan losses from the risky investment projects.[11] Under Basel I, total losses are higher than under the risk-based regime because of the overinvestment in high-risk projects. How is lending in the next period affected? If banks' are capital constrained in that their capital buffers are insufficient to absorb the losses and external capital is costly or simply difficult to get at short notice, banks will have to cut lending in order to absorb the

[11] Note that our analytical model has been static. However, when discussing procyclicality we essentially need to consider dynamic effects. We may think of an economy which starts in a boom in the first period and is then hit by a negative aggregate shock in the second period.

losses and not to violate the minimum capital requirement, which could be very costly. The lending cut may then fuel the economic downturn. This is the procyclical effect. Because losses are higher under Basel I, the procyclical effect is ceteris paribus, also more severe. Now consider that if Proposition 2 holds, a changeover to Basel II would increase the overall volume of lending which, other things equal, would expose the economy to more credit losses and hence more procyclicality.[12] Nonetheless, as the increase in lending volume would result from the increase in the number of low-risk projects which are less prone to losses in economic downturns, we would conjecture that Basel II's dampening effect on procyclicality through correcting the overinvestment in high-risk projects would dominate.

On the other hand, a negative shock to the economy would also raise the probability of default of the non-defaulted risky assets which hence are subject to a higher capital requirement under Basel II than under Basel I. Hence, the procyclical effect resulting directly from capital requirements is bigger under Basel II. This is the standard view why Basel II is considered to be the more procyclical capital regime. The net of the above effects remains an open issue: we can not say which of the two capital regimes is the more procyclical one. Nonetheless, our analysis of the portfolio effects of the two different regulatory capital regimes does suggest that Basel II may be less procyclical than hitherto understood. The uncertain overall effect on procyclicality of the two regimes also implies that we can not say for sure which of them implies a higher social welfare. We conjecture, however, that Basel II is a stronger candidate for being better for the social welfare because, in the light of our model, it can correct the fundamental overinvestment problem stemming from asymmetric information, which Basel I only makes worse.[13]

5 Concluding remarks

In this paper, we have investigated the effect of risk-based capital adequacy regulation, such as Basel II, on the efficiency of resource allocation in credit markets. Allocational efficiency is driven by entrepreneurs' self-selection among investments of different risk categories. The conventional result (eg De Meza and Webb, 1987) in this kind of setting is that there is too much risk-taking because low risk borrowers cross-subsidize high risk borrowers through the price system that is based on average success rates. We find

[12] For the corporate credit portfolio the lowest risk-weights of the Internal Ratings Based Approach of Basel II are clearly lower than the 8% flat-rate requirement of Basel I. Moreover, the goal of Basel II has been to calibrate the IRB risk-weights in such a way that the overall amount of capital in the banking sector does not change much. In this respect it is plausible to assume that Proposition 2 holds.

[13] Elizalde and Repullo (2006) state that 'In principle, regulatory capital should be derived from the maximization of a social welfare function that takes into account the costs (eg increase in the cost of credit) and the benefits (eg reduction in the probability of bank failure) of capital regulation.' In terms of Elizalde and Repullo (2006), the efficiency aspect of our model apparently relates to the cost of credit; that is, socially optimal capital regulation should also, if possible, ensure efficient credit allocation through the price system. Of course, there could also be a trade-off between efficiency and financial stability.

that a flat-rate capital requirement regime (such as Basel I) exacerbates this problem and it allocates too much investment in high-risk projects. The risk-based capital requirements, in turn, alleviate the cross-subsidization effect, improving allocational efficiency in the credit market. The ability of Basel II type of capital requirements to improve allocational efficiency, formalized in this paper, is important also in the light of the view that excessive risks may tend to build up during good times (see eg Borio et al, 2001, and Rajan, 1994). Moreover, lower capital requirement against less risky loans increases entrepreneurs' general participation in the credit market, so that the overall lending volume is higher under the risk-based capital requirements than under the flat-rate regime. It is also shown that there exists a risk-based capital requirement schedule that implements both the first-best loan composition and the first-best lending volume. We argue that the magnitude of the 'portfolio effect' resulting from the Basel II changeover can be substantial. This suggests that Basel II does not necessarily lead to exacerbation of macroeconomic cycles because the reduction in the suboptimally high proportion of high-risk investments, which may have resulted under Basel I, should mitigate the cyclicality of bank lending over the business cycle.

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