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PRO-CYCLICALITY OF CAPITAL REGULATION:
IS IT A PROBLEM? HOW TO FIX IT?

by Paolo Angelini[*], Andrea Enria[**], Stefano Neri[*], Fabio Panetta[*] and Mario Quagliariello[**]

Abstract

We use a macroeconomic euro area model with a bank sector to study the pro-cyclical effect of the capital regulation, focusing on the extra pro-cyclicality induced by Basel II over Basel I. Our results suggest that this incremental effect is modest. We also find that regulators could offset the extra pro-cyclicality by a countercyclical capital-requirements policy. Our results also suggest that banks may have incentives to accumulate countercyclical capital buffers, making this policy less relevant, but this finding is depends on the type of economic shock posited. We also survey different policy options for dealing with procyclicality and discuss the pros and cons of the measures available.

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Contents

1. Introduction[1]

Since the end of the 1980s, following the implementation of the Basel rules, G10 countries have introduced bank capital requirements based on risk-weighted assets. At the microeconomic level, the reasons for capital regulation include potentially excessive risk-taking by bank managers induced by flat-premium deposit insurance schemes[2] and insufficient monitoring of lending policies by small, dispersed depositors.[3] From a macroeconomic perspective, risk-based capital requirements are one of the tools available for reducing the externalities associated with bank failures (in terms, for example, of public funds needed in case of systemic crises or contagion across intermediaries).[4]

While there is strong rationale for their adoption, a potential drawback of risk-based capital requirements is that they could amplify the cyclical fluctuations of the economy (i.e. they may generate pro-cyclicality). In theory, in a frictionless economy they should not, but imperfections in capital markets do exist, and an accelerator mechanism may generate feedback from bank capital to the real economy (Adrian and Shin 2008). Therefore, risk-based capital requirements could generate pro-cyclicality, because risk itself is cyclical both in quantity and in value.[5] The debate on the additional pro-cyclicality generated by capital regulation, however, is still open. To conclude that capital regulation has pro-cyclical effects one should check, first of all, that it induces cyclicality in the minimum regulatory capital requirement under Pillar I, and that such cyclicality survives the supervisory review process under Pillar II (in principle, the regulator could take steps to attenuate it). Second, it should be ascertained that the banks' response to the regulatory changes does not offset the additional pro-cyclicality (e.g. via voluntary accumulation of countercyclical capital buffers). Finally, one should check that any resulting additional cyclicality in bank lending affects real activity.[6]

Although our knowledge about each of these conditions is very limited, in the aftermath of the current financial crisis a consensus has emerged that the Basel II capital rules should be amended. Widely discussed proposals, to be implemented once the crisis is over and phased in gradually, would focus on the level and the dynamics of bank capital. They include: strengthening the capital base of banks; implementing mechanisms for building capital buffers and forward-looking provisions in periods of buoyant growth for use in downturns;

[2] See Kohen and Santomero (1980), Kim and Santomero (1988), Rochet (1992).

[3] See Dewatripont and Tirole (1994).

[4] See Kashyap and Stein (2004).

[5] The amount of risk tends to increase during contractions, partly reflecting the process of accumulation during expansions (Borio et al. 2001). Similarly, the price of risk – that is, investors' risk aversion – decreases during upswings and increases during downswings (Lowe 2002).

[6] These conditions have been pointed out by a number of authors. See Taylor and Goodhart (2004) for example.

harmonising the definition of eligible capital and improving its quality; complementing Basel II rules with non-risk-based limits to leverage; introducing liquidity requirements (G20, 2009; FSF, 2009). The challenge is not reaching an agreement on general principles, but translating principles into concrete measures, which can be applied consistently across jurisdictions.

The current state of the debate prompts a series of considerations. First, the above-mentioned proposals for reform are generally analysed on a piecemeal basis, in the absence of a consistent framework that would allow a more structured approach to capital regulation. Moreover, the proposals pursue the twofold objective of increasing the resilience of the financial system and mitigating the pro-cyclical effects of capital regulation, at times without clearly distinguishing between the two. Finally, in our view, the recent contributions by regulators (Basel Committee 2010b, Macroeconomic Assessment Group 2010) and by the private sector (Institute of International Finance 2010) on the macroeconomic impact of the regulatory reform can be enriched with further cost-benefit analyses.

Moving from these considerations, this paper seeks to deal with these issues in a systematic way. We believe that a comprehensive framework should address the following fundamental questions: (i) Does the new Basel II regime really increase the pro-cyclicality of the banking system, and if so, by how much? (ii) Higher capital requirements would clearly strengthen the resilience of the financial system; could they also help attenuate the cyclical effects of credit on GDP, consumption and investment? (iii) What room is there for the management of countercyclical capital requirements? (iv) What is the macroeconomic cost (e.g. in terms of GDP growth) of policies to attenuate pro-cyclicality?[7]

To address these questions we cast the regulator problem within a macroeconomic model. Specifically, we build on the DSGE model developed by Gerali et al. (2009) to examine the functioning and possible shortcomings of risk-based capital regulation and potential policy measures designed to mitigate pro-cyclicality. The model features a simplified banking sector with capital, capturing the basic elements of banks' balance sheets: on the assets side there are loans to firms and households; on the liabilities side, deposits held by households and capital. We support this model by introducing heterogeneity in the creditworthiness of the various economic operators. We also introduce risk-sensitive capital requirements and quantify the extent to which they induce excessive lending and excessive GDP growth in booms, the reverse in downturns. We assess the effectiveness of stylised countercyclical tools on the basis of the model. In particular, we look at the response of the key macroeconomic variables to higher capital requirements and to passive and active countercyclical capital policies.

A final section is devoted to the practical aspects of the implementation of countercyclical capital rules. In particular, we focus on two tools: (i) the accumulation of Basel II capital buffers calibrated on downturn conditions (e.g. adopting simple correction factors based, for instance, on the ratio between downturn and current PDs); (ii) dynamic provisioning based on through-the-cycle expected losses. We argue that these tools may complement each other and are an essential element in any countercyclical toolkit.

The paper makes two main contributions to the literature. First, it studies the role of capital regulation in the context of a macroeconomic model, which allows us to examine the general

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[7]   A fifth crucial issue, which we do not address here, concerns the systemic nature of certain risks: risk-based capital regulation that only refers to individual banks underestimates systemic risk by neglecting the macro impact of banks reacting in unison to a shock (Brunnermeier et al. 2009).

equilibrium effects of changes in bank capital regulation. The DSGE model used in the paper belongs to a new class that explicitly comprises a (simplified) financial sector and features a meaningful interaction between this sector and the real economy. However, a caveat is needed. Our model is still far too simplified to be able to capture a number of essential elements of the financial sector, some of which arguably played an important role during the current financial crisis – e.g., maturity mismatches, derivative products, liquidity issues, heterogeneity across financial institutions. Regarding these clear weaknesses, it is worth recalling that the financial sector was entirely absent in the DSGE models of the previous generation. The financial accelerator mechanism of Bernanke, Gertler and Gilchrist (1999) has only recently been reconsidered in standard medium-scale DSGE models. One possible reason why the empirical literature, in particular, has generally not considered this mechanism is that it does not significantly amplify the effects of monetary policy shocks.

Second, we supplement this simplified but rigorous framework with a discussion of the main policy proposals. This approach stands in sharp contrast both with the existing literature on financial stability issues, typically based on reduced-form, partial-equilibrium models, and with the theoretical macroeconomic literature, typically not concerned with the practical implementation of policy proposals. We are aware of only one paper that studies the additional pro-cyclicality introduced by Basel II relative to Basel I in a similar macroeconomic framework: Aguiar and Drumond (2009). They find that the amplification of monetary policy shocks induced by capital requirement becomes stronger under Basel II regulation.

2. The macro framework

Until recently, the financial sector was largely overlooked in macroeconomic modeling. Seminal contributions, starting from Bernanke, Gertler and Gilchrist (1999), have begun to fill the gap by introducing credit and collateral requirements in quantitative general equilibrium models. More recently, models have begun to be designed to study the role of financial intermediaries in general and banks in particular (Christiano, Motto and Rostagno 2007, and Goodfriend and McCallum 2007). These models, however, mainly emphasise the demand side of credit. The credit spread that arises in equilibrium (called the external finance premium) is a function of the riskiness of entrepreneurs' investment projects and/or their net wealth. Banks, operating under perfect competition, simply accommodate the changing conditions from the demand side.

Gerali et al. (2009) instead build on the idea that conditions from the supply side of the credit markets are key to shape business-cycle dynamics. Starting from a standard model, featuring credit frictions and borrowing constraints as in Iacoviello (2005) and a set of real and nominal frictions as in Christiano et al. (2005) or Smets and Wouters (2003), they add a stylised banking sector with three distinctive features. First, banks enjoy some degree of market power when setting rates on loans to households and firms. Second, the rates chosen by these monopolistically competitive banks are adjusted only infrequently – i.e. they are sticky. Third, banks accumulate capital (out of retained earnings), as they try to maintain their capital/assets ratio as close as possible to an (exogenously given) optimal level. This optimal level might derive from a mandatory capital requirement (like those explicitly set forth in the Basel accords). In a deeper structural model, the optimum level might relate to the equilibrium outcome from balancing the cost of funding with the benefits of having more 'skin in the

game' to mitigate typical agency problems in credit markets. The model is estimated with Bayesian techniques using data for the euro area from 1998 to 2009.

Banks make optimal decisions subject to a balance-sheet identity, which forces assets (loans) to be equal to deposits plus capital. Hence, factors that affect the impact of banks' capital on the capital/assets ratio force banks to modify their leverage. Thus, the model captures the basic mechanism described by Adrian and Shin (2008), which has arguably played a major role during the current crisis.

In this paper we modify the model by Gerali et al. (2009) to study the role of capital regulation. More specifically, we assume that credit risk differs across categories of borrowers and introduce risk-sensitive capital requirements. We then show how optimal lending decisions of banks, and hence the macro environment, are affected by different regulations. We refer readers to the original paper for a more thorough description of the basic features of the model.

2.1 Main features of the model

The model describes an economy populated by entrepreneurs, households and banks. Households consume, work and accumulate housing wealth, while entrepreneurs produce goods for consumption and investment using capital bought from capital-good producers and labour supplied by households.

There are two types of households, which differ in their degree of impatience, i.e. in the discount factor they apply to the stream of future utility. This heterogeneity gives rise to borrowing and lending in equilibrium. Two types of one-period financial instruments, supplied by banks, are available to agents: saving assets (deposits) and loans. Borrowers face a collateral constraint that is tied to the value of collateral holdings: the stock of housing for households and physical capital for entrepreneurs.

As mentioned above, the banking sector operates in a regime of monopolistic competition: banks set interest rates on deposits and on loans in order to maximise profits. The balance sheet is simplified but captures the basic elements of banks' activity. On the assets side are loans to firms and households. On the liabilities side are deposits held by households and capital. Banks face a quadratic cost of deviating from an 'optimal' capital to assets ratio v.[8]

$$(1) \qquad \kappa_b \left(\frac{K_{b,t}}{L_t} - v \right)^2 K_{b,t}$$

where $K_{b,t}$ is bank capital, L_t is total loans and κ_b is a parameter measuring the cost of deviating from v. The latter can be thought of as a minimum capital ratio established by the

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[8]   The adjustment cost adopted in equation 1 is quadratic, and hence symmetric. An alternative, more realistic version should be asymmetric – the cost of falling below a regulatory minimum is arguably higher than the cost of excess capital. However, the first-order approximation of the model which we use throughout the current version of the paper would make such alternative adjustment cost immaterial for the results. In future work we plan to introduce an asymmetric adjustment cost (see Fahr and Smets 2008 for an application of downward nominal wage rigidities) and look at a second order approximation of the model, or simulate the nonlinear model.

regulator, plus a discretionary buffer. When the capital ratio falls below ν, cost increases are transferred by banks onto loan rates:

$$(2) \qquad R_t^i = R_t - \kappa_b \left(\frac{K_{b,t}}{L_t} - \nu \right) \left(\frac{K_{b,t}}{L_t} \right)^2 + markup_t, \qquad i = H, F$$

where R_t is the monetary policy rate and *markup* captures the effects of monopolistic power of banks on interest rate setting.[9] Equation 2 highlights the role of bank capital in determining loan supply conditions. On the one hand the bank would like to extend as many loans as possible, increasing leverage and thus profits per unit of capital. On the other hand, when leverage increases, the capital/assets ratio falls below ν and banks pay a cost, which they transfer on the interest rates paid by borrowers. This, in turn, may reduce credit demand and hence bank profits. The optimal choice for banks is to choose a level of loans (and thus of leverage) such that the marginal cost of reducing the capital/assets ratio exactly equals the spread between R_t^i and R_t. The presence of stickiness in bank rates implies that the costs related to the bank capital position are transferred gradually to the interest rate on loans to households and firms. Bank capital is accumulated out of retained profits π, according to the following equation:

$$(3) \qquad K_{b,t} = (1 - \delta_b) K_{b,t-1} + \Pi_{b,t-1}$$

where the term $\delta_b K_{b,t-1}$ measures the cost associated with managing bank capital and conducting the overall intermediation business.

Monetary policy is modelled via a Taylor rule with the following specification:

$$(4) \qquad R_t = (1 - \phi_R) \overline{R} + (1 - \phi_R) \phi_\pi (\pi_t - \overline{\pi}) + \phi_y (y_t - y_{t-1}) + \phi_R R_{t-1}$$

The values of the parameters of the model are reported in Gerali et al. (2009).

2.2 Key changes to the analytical framework

We have made a few changes to the basic framework of Gerali et al. (2009) in order to adapt it to our purposes. Specifically, we assume that loans to firms and to households are characterised by different degrees of riskiness captured, in a reduced form, by weights, w_t^F and w_t^H, which we use to compute a measure of risk-weighted assets.[10] The capital adjustment cost (1) is modified as follows:

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[9] In practice, a dynamic version of equation 2, in which bank rates are sticky, is employed in the model (see Gerali et al. 2009). It is assumed that banks, at any point in time, can obtain financing from a lending facility at the central bank at a rate equal to the policy rate R_t. A no-arbitrage condition between borrowing from the central bank and from households by issuing deposits implies that in equilibrium a dynamic version of equation 2 must hold.

[10] The model does not contemplate defaults, as they are ruled out as equilibrium outcomes (see Kyiotaki and Moore, 1997, and Iacoviello, 2005), but the device we adopt does mimic the effect of capital requirements based on risk-weighted assets.

$$(5) \qquad \kappa_b \left(\frac{K_{b,t}}{w_t^F L_t^F + w_t^H L_t^H} - v \right)^2 K_{b,t} ,$$

where total loans L_t is replaced by the sum of risk-weighted loans to firms (L_t^F) and households (L_t^H).

Note that setting $w_t^F = w_t^H = 1$ in expression 5 simulates the Basel I regime for loans to the private sector, whereas allowing the weights to vary over time captures the essence of the risk-sensitive Basel II mechanism. Under it, the inputs of the capital function can change through the cycle, reflecting either the rating issued by rating agencies or banks' own internal risk assessment models (the IRB approach). Under this second interpretation, we model the weights so as to roughly mimic their real-world setting by banks. We assume simple laws of motion of the form:

$$(6) \qquad w_t^i = (1 - \rho_i)\overline{w}^i + (1 - \rho_i)\chi_i (\log Y_t - \log Y_{t-4}) + \rho_i w_{t-1}^i \qquad i = F, H$$

where the lagged term w_{t-1}^i models the inertia in the adjustment of the risk-weights and the parameter χ_i (<0) measures the sensitivity of the weights to cyclical conditions proxied by the year-on-year growth rate of output.[11]

It is important to note that appropriate choices for the parameters in equation 6 also allow us to study the system dynamics under the two main rating systems allowed by the regulation: 'point in time' (PIT) v. 'through the cycle' (TTC). Essentially, to assess borrowers' creditworthiness under Basel II, banks can either use ratings supplied by external rating agencies, or produce their own internal ratings. Regardless of the source, ratings can be attained via either a PIT or a TTC approach. PIT ratings represent an assessment of the borrower's ability to discharge his obligations over a relatively short horizon (e.g. a year), and so can vary considerably over the cycle. The TTC approach focuses on a longer horizon, abstracting in principle from current cyclical conditions. TTC ratings are therefore inherently more stable than PIT ratings, although their predictive power for default rates is lower.[12] Within our framework, the TTC approach could be approximated by choosing a large value for ρ and a small one for χ in (6). At the limit, in this simplified setting a pure TTC system coincides with the Basel I framework.

Summing up, the results in the following sections can be interpreted as a comparison between the Basel I and Basel II frameworks, but also as a comparison between the PIT and the TTC approaches within the Basel II framework. While for the sake of brevity our comments refer mainly to the first interpretation, the second should also be kept in mind.

A final remark concerns the interpretation of v, the 'optimal' capital/assets ratio appearing in equations 2 and 5. As mentioned above, v can be thought of as a minimum capital ratio established by the regulator – e.g. the 8 percent benchmark imposed by the Basel regulation, plus a buffer. The buffer captures the idea that banks tend to voluntarily keep their capital

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[11] The results illustrated below remain broadly unchanged if the business cycle is measured using the deviation of output from its steady-state level.

[12] For a comparison of the PIT and TTC components of default risk, see Löffler (2008).

above the regulatory minimum, to avoid extra costs related to market discipline and supervisory intervention, or to meet market expectations (e.g. to maintain a given rating).[13] This twofold interpretation of v, as a regulatory instrument and as a capital buffer held by banks, has a key role in the present paper and must be borne in mind for the interpretation of our results. We shall come back to it in the following sections.

3. The pro-cyclicality of the Basel II framework: Is it a problem?

Whereas there is a relatively broad consensus that Basel I – like any capital regulation – increased the pro-cyclicality of the financial system, the issue of how much additional pro-cyclicality Basel II generates relative to Basel I is still open.[14] This issue is hard to address empirically, in view of the extremely recent application of Basel II (in Europe most banks deferred it to 2008). What scanty evidence there is derives from counterfactual and simulation exercises, or from comparisons with similar past experiences of regulatory change. Many authors argue that this extra pro-cyclicality may be substantial. However, the result often depends on the credit-risk estimation techniques chosen. In addition, other authors observe that banks hold capital buffers in excess of the regulatory minimum, and that this could enable them to smooth or even eliminate the impact of the new regulation on lending patterns.[15] Overall, a tentative summary of the available literature is that Basel II may increase the pro-cyclicality of bank lending, but that this conclusion must be treated with caution. Furthermore, as we argued in the introduction, little if any evidence is yet available on the impact of the new regulation on the real economy – i.e. on GDP and its components, and lending – which is what ultimately matters to assess pro-cyclicality.

This section develops that analysis. Specifically, we use the model augmented with the estimated versions of (6) to compare the model dynamics under Basel I and Basel II, and assess whether Basel II induces extra swings in bank variables and the key macro variables, and the size of these swings. To this end, we compute impulse-response functions to various shocks. We focus on technology shocks, which are arguably the main drivers of the business cycle, but we also consider monetary policy and demand shocks.

We use the parameterisation of the model reported in Gerali et al. (2009). To make the model operational we need to estimate the parameters of (6). Taking this equation to the data presents several challenges, due to the fact that no historical time series for the weights or the risk-weighted assets is available yet. To obtain estimates of the parameters of (6) we proceed as follows. We use data on delinquency rates on loans to households and non-financial companies in the US as proxies for the probabilities of default on these loans (similar data for the euro area were not available to us). We input these time series into the Basel II capital requirements formula, and using a series of assumptions concerning the other key variables of

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[13] See Furfine (2001).

[14] The Basel Committee was well aware of the potential pro-cyclical effects of the new regulations. The 'through the cycle' philosophy that permeates the accord, and several explicit provisions therein, were meant to curb pro-cyclicality. However, the evidence suggests that the implementation did not fully conform to the regulation's spirit. See Cannata and Quagliariello (2009).

[15] See Panetta et al. (2009) and Drumond (2008) for reviews of the literature on the pro-cyclicality of capital regulation, and for a summary of the debate on the pro-cyclicality induced by Basel I and Basel II.

the formula (loss given default, firms' size, loan maturity) we are able to back out time series for the weights w_t^F, w_t^H. Next, we estimate equation 6 using these series. The regressions suggest that the sensitivity of the risk weights to the cycle (the parameter χ) is relatively strong for commercial and industrial enterprises but not statistically different from zero for residential mortgages. Details on the methodology used to obtain the weights are reported in the Appendix 1.

3.1 Baseline results

Figure 1 shows the results for the technology shock, modelled as an unexpected increase in total factor productivity (TFP). Consider first the results under Basel I (represented in the figure by the dashed red lines).

The top two panels report the response of the key macroeconomic variables. The main effect works through investment: firms react to the positive technology shock by increasing investment by about 1 percent above its steady-state level in the first year (panel A). The expansion of output is relatively more muted and delayed (panel B), reflecting a more gradual pick-up in consumption. The increase in investment drives up the demand for loans, so that one year after the shock loan growth is about 0.9-1.0 percent above steady state (panel C).

Figure 1 - Impulse responses to a positive technology shock: Basel I v. Basel II
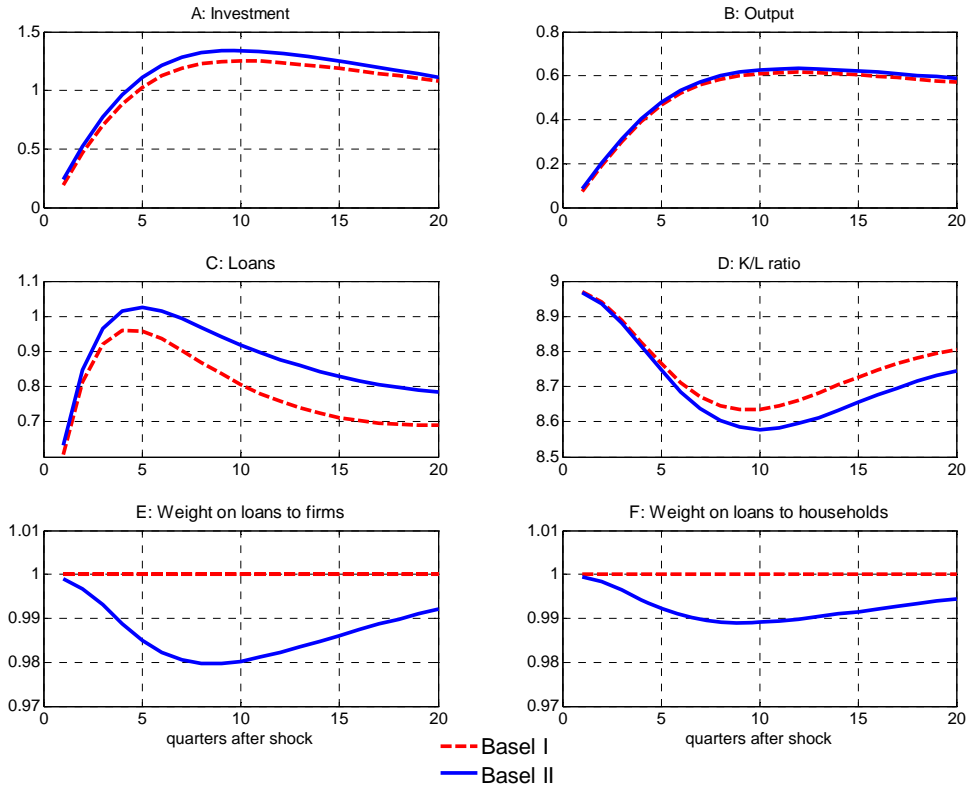
Note: The impulse responses are measured as percentage deviations from steady state, except for the *K/L* ratio (measured in percentage points) and the weights w^i (normalised to 1 and measured in levels).

The ratio between bank capital and assets declines over the first two or three years. The minimum value, close to 0.4 percentage points below the 9 percent steady-state value, is reached after 10 quarters (panel D). The decline reflects the increase in loans in the denominator (panel C), as well as a contraction of bank profits, which affects the numerator via the bank capital accumulation equation (3). The decline in profits is related to the decrease in the policy rate by the central bank in response to the decline in inflation, and to the presence of a mark-up on the loan rates and a mark-down on deposit rates. The mark-up and the mark-down are sticky. Hence, as the policy rate is reduced by the central bank, the interest rate margin falls and, since the price effect dominates the quantity effect, so do profits.[16] Notice that by construction the weights w_t^i in panels E and F do not move, as under Basel I they are fixed at 1.

Consider next the same exercise under Basel II (represented by the solid blue lines). In a nutshell, the system's responses are qualitatively similar, but slightly more pronounced than in the Basel I scenario. The reduction in the risk weights w_t^i is the key driver of the system's enhanced response. Both weights decline in the two years after the shock, reflecting improved macroeconomic conditions and the related decrease in the riskiness of the loans. The sharper decline of w_t^F is due to its higher sensitivity to cyclical conditions (a higher χ_i in (6)). This drives the ratio between banks' capital and risk-weighted assets away from the desired value v. To boost loans and reduce this gap, banks reduce interest rates on loans more aggressively than under Basel I.

The response of bank credit is always above the corresponding curve under the Basel I framework. The effect is relatively small, however. A similar reaction emerges for banks' capital/assets ratio.[17] The expansion in bank credit boosts investment growth: the deviation from steady state peaks about two years after the shock, at about 1.4 percent, compared with about 1.3 under Basel I. The effect on output is also magnified but muted.

Figure 2 shows the results for an expansionary monetary policy shock. The effects on the macroeconomic variables are qualitatively analogous to those in Figure 1: in the first 8-10 quarters the curves for Basel I are systematically below those for Basel II. However, the difference is negligible, as the curves virtually overlap. The limited impact of Basel II reflects the behaviour of the time-varying weights w_t^i: whereas the technology shock described in Figure 1 induces a large and persistent decline in the weights, the monetary policy shock causes a reduction of the risk weights that is too small and short-lived to alter the dynamics of the bank and macro variables significantly. In turn, this is due to the small and short-lived reaction of output to a monetary policy shock (a relatively common finding in the DSGE literature). The small additional pro-cyclicality induced by Basel II according to the exercises in Figure 2 echoes several findings in the literature, according to which financial frictions do not significantly amplify the transmission of monetary policy shocks (see, among others, De Fiore and Tristani 2009, De Graeve 2008 and Iacoviello 2005). At the same time, our result is in contrast with Aguiar and Drumond (2009), the only other paper which focuses on the Basel I v Basel II issue within a DSGE framework. They find that, in the case of a monetary policy shock, the impact of Basel on the model dynamics in general and on output in particular is

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[16]   Empirically, the differential between loan and deposit rates is countercyclical. See e.g. Aliaga-Diaz and Olivero (2008) for evidence on the US.

[17]   This decline is also due to the fall of bank profits, which is sharper under Basel II.

larger than in our case (both for the effect of Basel I, and for the Basel II v. Basel I differential).[18]

As a third experiment, we examined a positive demand shock, modelled as a decrease in the intertemporal discount factor that induces both types of household to anticipate consumption and reduce savings. This type of disturbance, which directly affects households' inter-temporal first-order conditions, is commonly considered in estimated medium-scale models (see Primiceri et al. 2006 and Smets and Wouters, 2007). One of its characteristics, in these models, is that it typically generates opposing movements in consumption and investment. This does not match the pattern observed in reality, as in most economies the correlation, along the business cycle, between consumption and investment is strongly positive. Thus, the quantitative importance of these shocks for the business cycle tends to be relatively modest, and the positive correlation between consumption and investment may reflect other, more important drivers of the business cycle (e.g. technology shocks, which push consumption and investment in the same direction).

Figure 2 - Impulse responses to a positive monetary policy shock: Basel I v Basel II
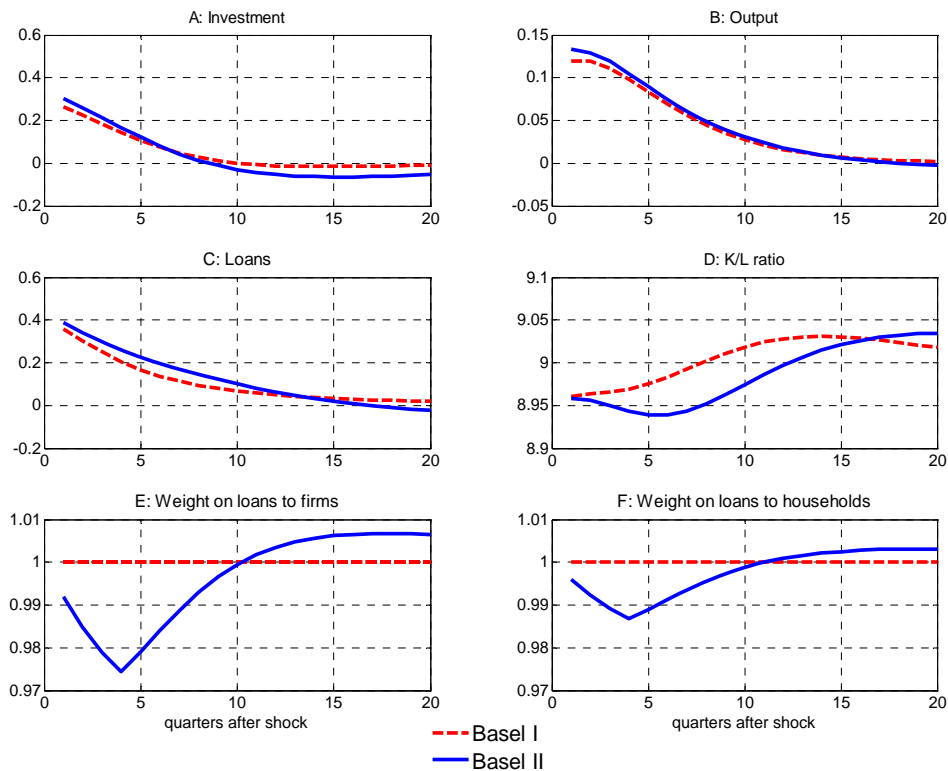
Note: the impulse responses are measured as percentage deviations from steady state, except for the *K/L* (measured in percentage points) and the weights w^i (normalised to 1 and measured in levels).

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[18] This difference may be due to alternative modeling choices. Aguiar and Drumond (2009) build on the Bernanke, Gertler and Gilchrist (1999) framework, whereas our model is based on the financial accelerator mechanism of Kyiotaki and Moore (1997).

The debate on this issue is clearly beyond the scope of this paper. For our purposes, it is important to remark that following this type of demand shock investment falls, and so does bank lending; these movements are attenuated (i.e. the contraction is more modest) under Basel II. Overall, output growth is (slightly) stronger under Basel II, as the growth in consumption offsets the fall in investment.[19] Thus, using the strict GDP-based interpretation of the definition of pro-cyclicality proposed in the introduction (an arrangement is pro-cyclical if it amplifies the cyclical fluctuations of the economy), we can still conclude that adoption of Basel II produces a (modest) increase in pro-cyclicality. However, the muted contraction of bank loans (and investment) under Basel II makes one wonder whether simply looking at the behaviour of output is the proper thing to do.

Summing up, our findings suggest that the transition from Basel I to Basel II can amplify the dynamics of bank lending and of the capital/asset ratio and, ultimately, the fluctuations of the real economy. Furthermore, recalling that our exercises in Figures 1 and 2 can also be interpreted as a comparison between the PIT and TTC rating approaches under Basel II, our evidence also suggests that the PIT approach introduces extra pro-cyclicality relative to the TTC. Our key finding, however, is that the magnitude of this amplification effect is relatively small.[20]

This assessment has to be qualified with two caveats. First, there are at least two reasons why, *ceteris paribus*, the above exercises may overestimate Basel II's incremental pro-cyclicality. One is that they only partially incorporate banks' optimal response to shocks and regulatory changes. As we discuss below, several authors contend that forward-looking banks will react to Basel II by holding voluntary countercyclical buffers. By contrast, we have assumed so far that v (the parameter pinning down the steady-state value of banks' capital/assets ratio) does not vary over time. We shall address the issue of a time-varying v in section 5.1. Another potential source of overestimation is that our estimates of equation 6 are based on quarterly delinquency rates, and should therefore approximate a pure PIT approach.

Second, several shortcomings of the model may have an ambiguous impact on the magnitude of the effect we are investigating, thereby increasing the confidence interval around our assessment. Other features not yet discussed are likely to generate an underestimation of this effect. We discuss them in section 5.

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[19] The decrease in households' discount factor makes them more impatient and causes an increase in consumption and output, and a reduction in savings (deposits fall by around 0.6 percent). The fall in deposits forces banks to reduce lending to firms (who cut investment spending) and to households. The initial increase in spending on capital goods reflects the large increase in the price of firms' installed capital stock. The fall in risk-weighted loans and the slow increase in bank capital, resulting from higher profits, raises the capital/asset ratio above the desired value v. As for the technology shock, both weights decline in response to the demand shock. Profits increase under Basel I but fall under Basel II. This difference reflects the response of loan rates, which increase more under Basel I than under Basel II.

[20] Our assessment of the pro-cyclicality of capital regulation may be affected by the parameter measuring the costs of adjusting the capital/assets ratio, κ_b, in equation 1. We analyse the issue in section 3.2 below.

3.2 Robustness

Our results are sensitive, *inter alia*, to the estimated values of ρ and χ, whose point estimates are subjected to particular uncertainty, for the reasons just mentioned. Therefore, we now assess the sensitivity of our findings to alternative values for ρ^i and χ^j, the key parameters in equation 6. We gauge the impact of modifying these parameters on output and bank loans, the key variables that characterise the results of Figures 1 and 2. We replicate the exercise underlying the figures under different values of ρ^i and χ^j. These figures are judgmental – i.e. they are not estimated – and their only aim is to test the robustness of our results. In Table 1 we only report the results for the technology shock, as those for the monetary policy shock remain virtually unchanged.

For ease of comparison, the intersections of the rows and columns labelled 'baseline' report results from Figure 1, Basel II scenario. For instance, consider the effect of the technology shock on output (left-hand side of the table). Using the baseline estimates of ρ^j and χ^j one obtains a maximum deviation of investment from its steady-state value of 0.6 percent. This value is the maximum of the impulse-response curve of output under the Basel II regime, reached after about 7 or 8 quarters (Figure 1.B). Likewise, the maximum effect on loans, 1 percent of the steady-state value, reached after 5 quarters, can be read from Figure 1.C.

Table 1 - Sensitivity of results to parameterisation of equation (6): technology shock
(*Maximum effect; percent deviations from steady state*)

		Effect on output (0.6 under Basel I)			Effect on loans (1.0 under Basel I)		
		ρ^j			ρ^j		
		0.70	Baseline	0.97	0.70	Baseline	0.97
χ^j	Baseline	0.6	0.6	0.6	1.1	1.0	1.0
	Baseline * 5	0.7	0.7	0.7	1.9	1.4	1.1
	Baseline * 10	0.8	0.9	0.7	3.1	2.4	1.5

Note: The baseline values for χ^j and ρ^i ($i=F, H$) are those reported in the appendix, and used in Figures 1 and 2. The estimated ρ is in the range 0.90-0.93 (that is, it is greater than 0.7 and less than 0.97) for both households and firms.

The other cells of the table report the results of three exercises. First, we keep the autoregressive parameters ρ^j fixed at their estimated baseline levels, and increase the sensitivity χ^j of the weights to the business cycle. Second, we move the autoregressive parameters ρ^j above or below their estimated baseline levels while keeping the χ^j at their baseline values. Finally, we allow both parameters to differ from the baseline. Note that the low-ρ^j, high-χ^j cells can also be interpreted as corresponding to a version of the PIT rating approach more extreme than that under our Basel II baseline scenario in Figures 1 and 2. By contrast, the high-ρ^j, low-χ^j cells could be viewed as capturing a TTC less extreme than under our Basel I scenario in Figures 1 and 2.

Overall, this robustness check confirms the results of Figures 1 and 2. Consider first the effect on output (left-hand side of the table). In all cases the introduction of Basel II increases the pro-cyclicality relative to Basel I. Pro-cyclicality is also increased when moving from less to more PIT rating systems, i.e. moving from the upper-right to the lower-left corner of the table

(although a slight non-monotonicity appears in the figures: the effect under $\rho^j=0.7$ is slightly larger than under the baseline value, which is above 0.9). The magnitude of the effects induced by the Basel II regulation is almost insensitive to the autoregressive parameter ρ^j, relatively more sensitive to the χ^H, χ^F parameters: assuming that the true values of these parameters are 10 times larger than the estimated baseline, the pro-cyclical effect on output increases from 0.6 to 0.9 in terms of maximum deviation from the steady-state value. Overall, the effects would remain modest even if we were to admit that our baseline χ^j was significantly underestimated.

Next, look at the effect on lending, on the right-hand side of the table. The above effects are confirmed from a qualitative viewpoint, but become more sensitive to the choice of ρ^j and χ^j. In reaction to the technology shock, lending increases to a maximum of 2.3 percent of the steady-state value when χ^j are 10 times larger than the estimated baseline, compared with 1 percent when the baseline values are used.

We also check the sensitivity of the results to the estimated value of κ_b, the parameter measuring the cost of deviating from the optimal capital/assets ratio ν in (1). To this end, we increase this parameter up to 10 times its baseline value, and compute the impulse responses for technology, monetary policy and demand shocks. These simulations reveal that the effect of this parameter is relatively large in the Basel I scenario (following a technology shock, the expansion of loans and investment is smaller if κ_b is larger); however, the difference between Basel II and Basel I is only marginal.

3.3 Summary

In this section we have shown that the shift from Basel I to Basel II increases the pro-cyclicality of bank lending – i.e. that the reaction of macroeconomic variables such as output and investment to shocks is relatively larger under the Basel II than the Basel I regime. However, our results indicate that the magnitude of this amplification effect depends on the type of shock considered, and appears contained.

This conclusion is subject to a series of caveats. To begin with, the magnitude depends on a number of model features (discussed in section 5), which make our estimate particularly uncertain at this stage. In addition, admitting that the extra pro-cyclicality induced by Basel II is small does not imply that nothing should be done about it: if the cost of eliminating it were likewise small, then it would be optimal to address the problem. Finally, Aguiar and Drumond (2009), who employ a similar DSGE framework to address the issue, find that the amplification effect induced by Basel II is larger than suggested by our estimates.

Therefore, in the rest of the paper we consider possible remedies to the pro-cyclicality induced by the Basel II regulation, assessing their costs and benefits.

4. Assessing costs and benefits of countercyclical measures

A number of policy proposals to reduce the pro-cyclicality induced by Basel II have been advanced. Section 6 reviews and discusses these proposals in some detail. In short, they can be grouped under the following headings: (*i*) smoothing the inputs of the capital function (for instance, banks could be required to mitigate the cyclicality of their PIT estimates of the PDs, or to go over to TTC estimation methods); (*ii*) adjusting the capital function (for instance, some parameters such as the confidence level or the asset correlations could be appropriately changed over the cycle); (*iii*) smoothing the output of the capital function (i.e. allow capital requirements to move in an autoregressive or countercyclical fashion); (*iv*) adopting countercyclical capital buffers; (*v*) adopting countercyclical provisions.

For the purposes of this section, it is enough to remark that the model with which we work does not allow us to distinguish among these proposals (as it makes no distinction between capital and loss provisions, say). However, it does allow us to assess their macroeconomic effects if one is willing to overlook the (important) technical differences among them, and concentrate instead on their common denominator. In our view, the common denominator is the idea that capital (or provisions) should be adjusted in a countercyclical fashion.

In the next subsection we gauge the effects on pro-cyclicality of countercyclical (regulatory or voluntary) capital buffers. In section 4.2 we assess the impact of higher capital requirements.

4.1 Instituting a countercyclical capital requirement

So far, we have worked under the assumption that the key parameter v is time-invariant. This is in keeping with the current policy framework, under both Basel I and II, and with the idea that banks like to keep voluntary capital buffers constant at the lowest possible value. However, a natural extension is to consider a time-varying v. Within our framework, this represents the most straightforward way to assess the effect of countercyclical capital requirements. Consider the following equation:

(7) $$v_t = (1 - \rho_v)\bar{v} + (1 - \rho_v)\chi_v(\log y_t - \log y_{t-4}) + \rho_v v_{t-1}$$

where the parameter $\bar{v}$ measures the steady-state level of v. In (7), we assume that v_t adjusts to year-on-year output growth, our measure of the business cycle, with a sensitivity equal to the parameter χ_v. Assuming that the latter is positive amounts to imposing a countercyclical regulatory policy: capital requirements increase in good times (banks hold more capital for the amount of loans they provide to the economy), and decrease in bad times.

Note that adding (7) to the model affects the cyclical pattern of the main variables but not their steady-state levels, and is therefore neutral in this sense. The reason is that the steady state of the model is affected only by the value of $\bar{v}$ and not by the dynamics of v, which are influenced by the sensitivity of capital requirements to output. Therefore, in what follows we focus on the effects of adopting (7) on the dynamics of the economy.

Recall from section 2 that v has a twofold interpretation: as a capital requirement and as a buffer voluntarily held by banks. This interpretation carries over to v_t and to equation (7): the regulator might decide to institute a countercyclical capital requirement; alternatively, banks might voluntarily choose to hold countercyclical capital buffers. In the following section, we look at these two interpretations.

4.1.1 Countercyclical management of capital requirements

Is there room for countercyclical capital requirements? At first sight, the answer seems to be no, within our model as well as in general: the Taylor rule, which closes the model, is the natural countercyclical tool, and it would seem that any new instrument for that purpose should at best be collinear with monetary policy, and at worst conflict with it (e.g. if the responsibility for the new instrument were assigned to another authority and co-ordination between the two authorities were limited). But models, including ours, feature several frictions, some of which are related to the presence of nominal rigidities (prices and wages) and others to the presence of borrowing constraints on households and firms. Therefore, an additional instrument might improve upon the result attainable when only monetary policy is available.[21]

The literature has only very recently started studying optimal monetary policy in the context of models with financial frictions. Cúrdia and Woodford (2009) find that in the simple new Keynesian (NK) model with time-varying credit (arising because of financial frictions) the optimal target criterion (i.e. the optimal monetary policy) remains exactly the same as in the basic NK model: the central bank should seek to stabilise a weighted average gap between inflation and output. In the context of a similar small-scale model, De Fiore and Tristani (2009) show that in the presence of a credit channel, near-full inflation stabilisation remains optimal in response to specific shocks.

In this section we interpret equation (7) as a simple capital requirement reaction function, where the parameter $\bar{v}$ measures the steady-state level of capital requirements v_t and $\chi_v > 0$ measures its sensitivity to the business cycle. As in section 3, we look at the effects of the introduction of (7) on the dynamics of the model by examining the responses to various shocks. For comparison, the figures report the curves from Figures 1 and 2 obtained under Basel I, a useful baseline since we have seen that its pro-cyclicality is a lower bound.

The results are in Figure 3.

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[21] Woodford (2003) shows that in a simple economy with one friction, optimal monetary policy is capable of restoring the first best allocation. However, Erceg, Henderson and Levin (2000) show that in an economy with staggered wage and price setting, strict inflation targeting can induce substantial welfare costs. This result suggests that when more than one friction is present, policymakers may want to resort to multiple instruments to maximise society's welfare.

Figure 3 – Impulse responses with passive v countercyclical capital requirements
3.1 Positive technology shock
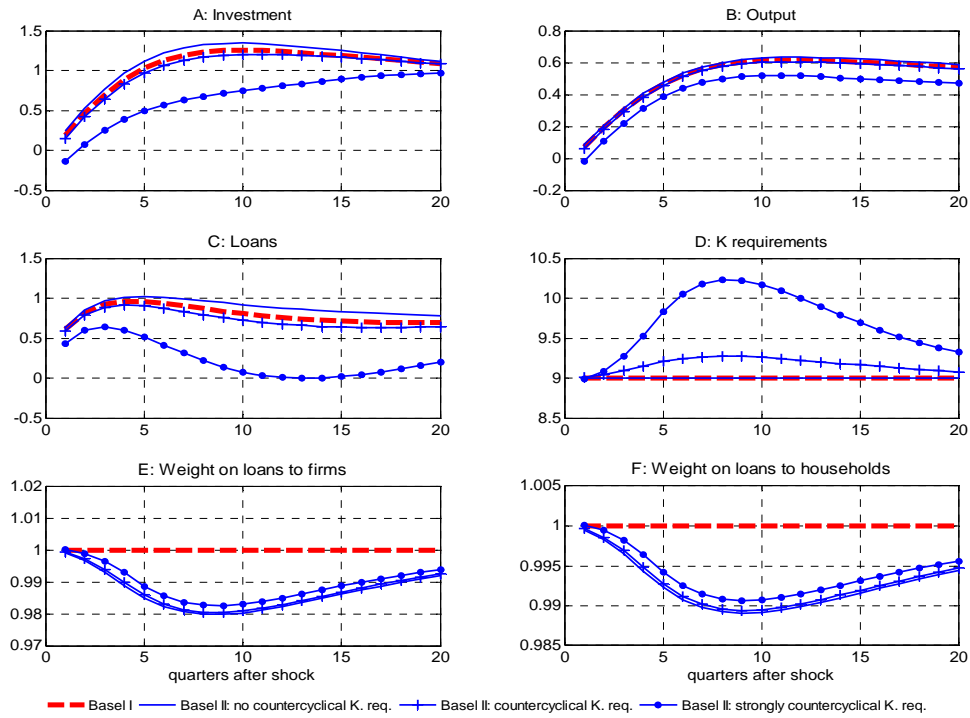
3.2 Expansionary monetary policy shock
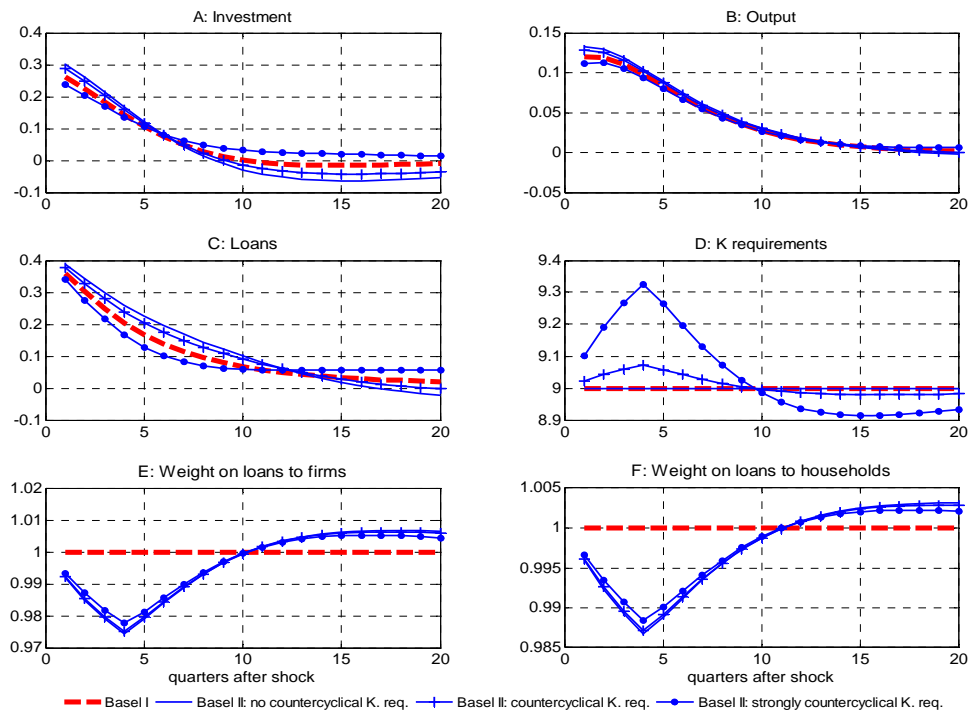
Note: The impulse responses are measured as percentage deviations from steady state, except for the capital requirement (measured in percentage points); the responses of weights w^i are normalised to 1 and measured in levels. To ease the interpretation, in panel 2 the curves have been computed using a value of χ^j in (5) five times larger than the baseline.

As usual, we start with a positive technology shock. Consider the responses of investment, in panel 3.1.A. The two top lines illustrate the reaction under Basel I (blue) and Basel II (dotted red). They are exactly those reported in Figure 1, for ease of comparison. The two new lines are obtained with a countercyclical management of the capital requirement – i.e. simulating the model augmented with equation (7). Specifically, the solid blue curve labelled 'Basel II: countercyclical K requirement' is obtained by setting $\rho_v = 0.90$ and $\chi_v = 20$ in (7). The figure clearly shows that this policy can undo the extra pro-cyclicality induced by Basel II relative to Basel I, and indeed, can improve upon Basel I. How is this stabilisation achieved? The basic mechanism is the same as illustrated in section 3. The stabilisation policy attenuates lending growth (panel C). In turn, this is due to the fact that the expansion of output drives up the capital requirement v_t. The above parameterisation for ρ_v and χ_v in (7) causes v_t to gradually increase from its steady state of 9 percent to a maximum of 9.3 percent after about 8 quarters (panel D).

The response of output, in panel B, confirms this message from a qualitative viewpoint, although the small size of the effects, documented in section 3, causes the curves to be very similar. Notice that in this case the risk weights in panels E and F are hardly affected, and consequently play a minor role.

To assess the sensitivity of the results we simulated the model setting $\chi_v = 100$. The resulting responses are labelled 'Basel II: strongly countercyclical K requirement'. A look at the usual sequence of panels in figure 5.1 reveals significant changes. The responses of investment and output are now well below the Basel I benchmark, indicating that the attenuation of pro-cyclicality is now relatively marked. This effect is obtained with a 1.2 percentage point increase in the capital ratio, from the steady-state value of 9 percent to a peak of 10.2 percent after about two years. The order of magnitude of this increase is plausible.

According to the interpretation that we adopt in this section, equation 7 is a policy reaction function. Hence its parameters could be chosen optimally, so as to minimise pro-cyclicality, say, or maximise welfare. We leave this task for future research. The point of the simple exercise just described is to show that a countercyclical capital requirement policy can achieve relatively powerful results.

Panel 2 of Figure 3 replicates the exercise for a monetary policy shock. Overall, the results of panel 1 are qualitatively confirmed. As in previous sections, the difference across the different regulatory regimes turns out to be small for this type of shock. In this case, the 'countercyclical K requirement' policy manages to improve on the passive policy, but still leaves more pro-cyclicality than under the Basel I framework. To improve on the latter, the 'strongly countercyclical K requirement' policy should be adopted.[22]

Overall, our results suggest that introducing policy tools that allow building up and using buffers of resources in a countercyclical fashion may yield benefits, relative to an

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[22]   As with previous cases, we also consider a demand shock. The results (not reported) confirm the analysis of the previous sections. Conditioning on this type of shock, the success of the countercyclical K requirement policy is clear cut if one sticks to the strict definition of pro-cyclicality (output increases, and the increase is attenuated under the countercyclical policy); it is ambiguous if one considers the entire economy (loans and investment decline, and the decline is sharper under the countercyclical policy).

environment in which the only policy instrument is the interest rate. The practical implementation of this countercyclical capital requirements policy is the subject of section 6. As we shall see, such a policy need not be discretionary – i.e. its implementation need not require periodic meetings of a board, as it could be based on rules.

4.1.2 Would banks voluntarily adopt a countercyclical capital policy rule?

In our simplified framework, v_t can be thought of as comprising a buffer voluntarily held by banks (e.g. to face unexpected losses) because the current version of the model does not distinguish between capital and provisions. Therefore, one may view equation 7 as an admittedly rough way to let banks – not the regulator – choose a (possibly countercyclical) capital buffer. Indeed, as mentioned above, various authors (Repullo and Suarez 2008 and Tarullo 2008) argue that forward-looking banks will find it optimal to manage their excess capital buffers in a countercyclical fashion, and that this endogenous response could significantly offset the extra pro-cyclicality induced by the new regulations.[23] If this were the case, regulatory intervention on capital requirements could prove to be largely superfluous.

A straightforward way to check whether this is the case within our framework is to look at bank profits (the interest rate margin, more precisely) under Basel II, with and without the countercyclical capital policy (7). Clearly, if banks can increase profits by voluntarily adopting countercyclical capital buffers, they will not wait for the regulator to intervene before implementing such a policy.

Figure 4 reports the impulse response of banks' gross profits (i.e. before capital depreciation) to the usual technology and monetary policy shocks under the four regimes discussed in the previous section: the Basel I and Basel II regimes underlying Figures 1 and 2; and the Basel II regime with the countercyclical and 'strongly' countercyclical policy (7) underlying Figure 3.

Look at the first panel, reporting the response of bank profits to a technology shock. Gauged with the yardstick of bank profits, the worst regime is Basel II with fixed capital buffers; next comes the Basel I regime; then, the Basel II with time-varying, countercyclical capital buffers ('countercyclical K requirement'). The best is Basel II with strongly countercyclical K requirement. Thus, it seems that a countercyclical accumulation of voluntary capital buffers would be in the banks' own interest.

Next, consider panel 2, reporting the response of profits to the expansionary monetary policy shock. Here the results become ambiguous. Specifically, the ordering of the curves depends on the time horizon: a policy of countercyclical capital build-up would initially harm profits. When a countercyclical policy is implemented, capital requirements are increased exactly when the capital/assets ratio falls because of the expansion in lending. As a consequence, the fall in bank loan rates induced by the expansionary monetary policy is partly offset by the increase in costs related to the banks' capital position (see equation 2) and, consequently, profits fall by a larger amount. Overall, the figure suggests that banks would shy away from such a policy. As usual, we also considered a positive demand shock. The indications from the related figure (not reported) are in line with that of panel 1.

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[23]   Repullo and Suarez (2008) suggest that these buffers would range from about 2 percent of total assets in recessions to about 5 percent in expansions.

Summing up, several authors argue that, faced with the Basel II regulatory change, banks will find it optimal to offset the additional pro-cyclicality at least partially by appropriate voluntary capital buffers. Our analysis provides only partial support for this argument. As is often the case in the context of analyses conducted with DSGE models, the effectiveness of certain economic actions is not uniquely determined but conditional on the type of shock posited. As such, our results lend support to the view that a policy of countercyclical capital requirements, enforced by a regulator, would not be superfluous.

Figure 4 - Impulse responses of bank profits under alternative regulatory regimes
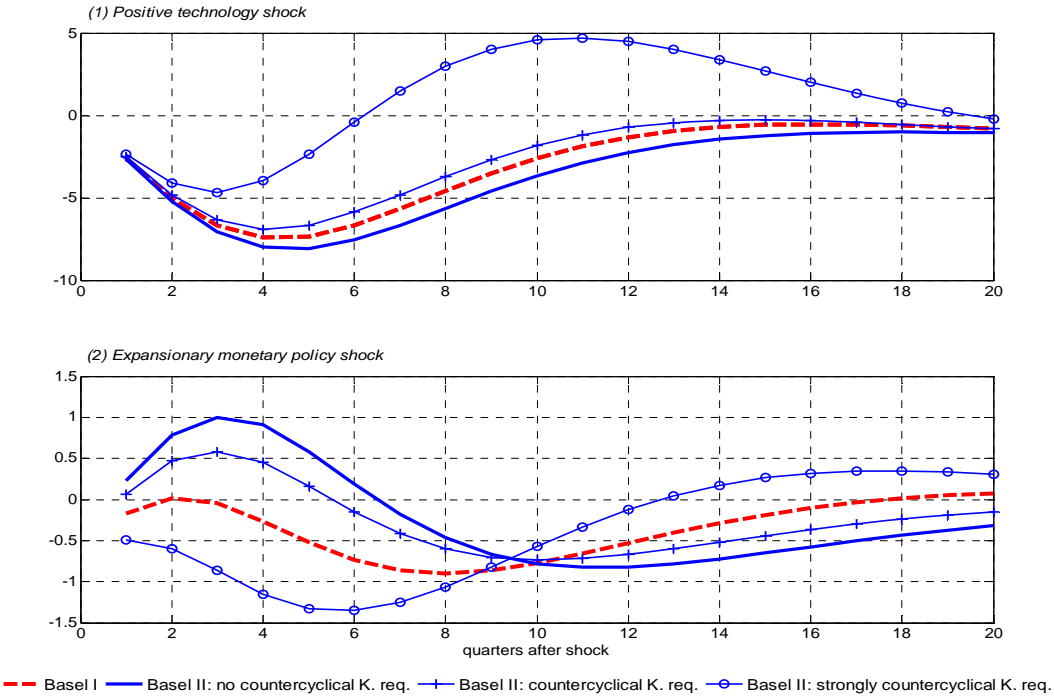
Note: The impulse responses are measured as percentage deviations from steady state. To facilitate interpretation, in panel 2 the curves have been computed using a value of χ^j in (5) five times larger than the baseline.

4.2 Increasing banks' regulatory capital

Due to the crisis, proposals to raise the regulatory minimum capital above 8 percent and to improve capital quality have regained popularity. It is widely acknowledged that excessively low capital levels were helped to propagate the financial crisis. Relatively small losses, concentrated in time and affecting many intermediaries at once, triggered a deleveraging that had far-reaching consequences. Clearly, the adjustment could have been much less dramatic if the capital base had been larger – i.e. if the system's leverage had been lower. However, in the current policy debate proposals to increase banks' regulatory capital are seldom explicitly motivated with the need to reduce pro-cyclicality (see FSF 2008 and 2009 for example). This is probably due to the fact that the link between pro-cyclicality and the level of capital is not obvious. Intuitively, one could think that, as long as the cost borne for deviating from the

minimum requirement is unchanged, it is immaterial whether the minimum is set at 8 percent or some much higher level.[24]

Within our model an increase in v does have an effect on the dynamics of the key macroeconomic variables.[25] In more intuitive terms, the effect of v on the system dynamics may be seen as working through bank leverage: raising v increases the steady-state value of the capital/assets ratio, reducing leverage. While this should univocally attenuate the accelerator effect and therefore reduce pro-cyclicality, in practice we will see that the result is ambiguous. Thus, we have first assessed whether higher capital requirements increase or decrease pro-cyclicality. Next, we look at the macroeconomic costs of higher capital requirements.

For the first task, we use the baseline parameterisation of our model to compute impulse-response functions of bank variables and key macroeconomic variables to different shocks, adopting several different, plausible values for v. Figure 5.1, the counterpart of Figure 1, reports the reaction to a positive technology shock. The curves labelled v =0.09 are those of the baseline exercises in Figure 1, reported for ease of comparison. The figure suggests that higher capital requirements attenuate the reaction of the key bank variables: the curves for loans and the capital/assets ratio corresponding to higher v are relatively closer to zero (panels C, D).[26] In turn, the dynamics of loans affect investment (panels B, C) and output.

Figure 5.2 replicates the same exercise for an expansionary monetary policy shock. Since under the baseline parameterisation the curves virtually overlap in all the panels, we plot the responses obtained setting χ_i 5 times larger than the baseline; this magnifies the differences without altering their sign. The results appear now to be reversed, although they are not clear-cut.

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[24] This point is well summarised by Brunnermeier *et al.* (2009): "requirements based on minimum capital ratios do not provide resilience, since they cannot be breached. They represent a tax, not a source of strength". Accordingly they suggest introducing higher target levels of capital, with a specific, rule-based ladder of increasing sanctions.

[25] There are two indirect (and technical) effects. First, the depreciation parameter δ_b in equation (3) is determined by the parameter v (via a series of conditions discussed in Gerali et al. 2009, which we have omitted from section 2). Thus, increasing v causes a decline in δ_b which affects the dynamics of capital accumulation via (3). Second, looking at the log-linear approximation to equation 2 used to derive the impulse response functions presented throughout the paper, one can see that a higher v implies that a given deviation of the capital/assets ratio has a greater effect on the interest rates set by banks.

[26] The curves in Figure 3 are derived from models with different steady states. They are comparable because they are expressed in terms of percentage deviation from the steady state.

Figure 5 - Impulse responses under different levels of capital requirements

(1) positive technology shock
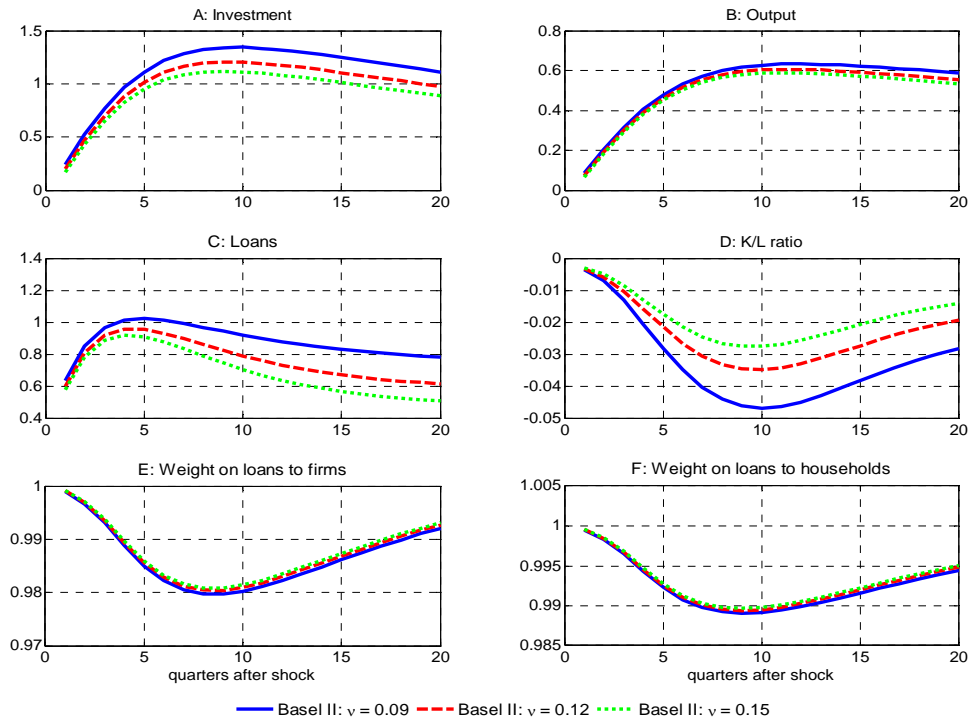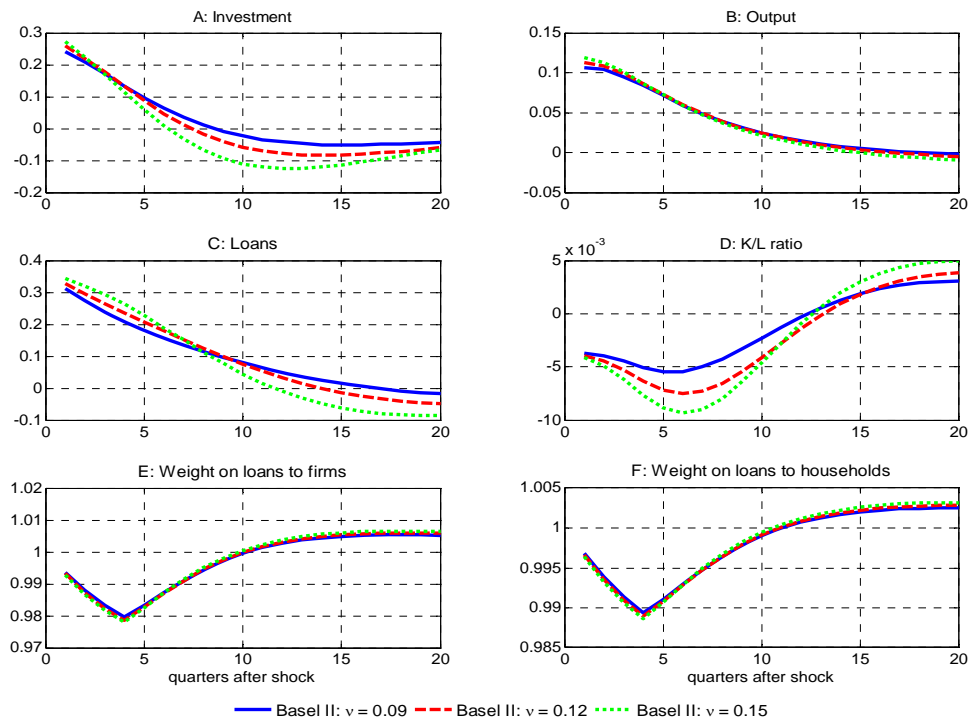
A: Investment | B: Output | C: Loans | D: K/L ratio | E: Weight on loans to firms | F: Weight on loans to households

Basel II: $\nu = 0.09$ — Basel II: $\nu = 0.12$ — Basel II: $\nu = 0.15$

(2) Expansionary monetary policy shock

A: Investment | B: Output | C: Loans | D: K/L ratio | E: Weight on loans to firms | F: Weight on loans to households

Basel II: $\nu = 0.09$ — Basel II: $\nu = 0.12$ — Basel II: $\nu = 0.15$

Note: The impulse responses are measured as percentage deviations from steady state, except for the capital requirement (measured in percentage points); the responses of weights w^i are normalised to one and measured in levels. To facilitate interpretation, in panel (2) the curves have been computed using a value of χ^j in (5) five times larger than the baseline.

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The rate of growth of bank loans is higher in the first 6 to 7 quarters after the shock, but becomes lower afterwards. Increasing the capital requirement seems to have a pro-cyclical impact on investment and output, although the effects are negligible and short-lived.

As in section 3.1, we also considered a positive demand shock (figure not reported). The results obtained with the baseline parameterisation of the model are somewhat ambiguous: the response of output is positive and increasing in v. Loans decline, reflecting the fall in investment. However, the fall is less sharp for higher values of v. Overall, the difficulties of interpreting the outcome of this exercise mirror those discussed in section 3.1.

Finally, we analysed the robustness of these results compared with alternative choices of the key parameters in equation 6. For values of χ^j 5 or 10 times larger than the baseline, the result of Figure 3.1 vanishes: it is no longer true that higher values of v yield lower pro-cyclicality – indeed, they tend heighten pro-cyclicality. Figure 5.2 is already drawn under the assumption of χ^j 5 times larger than the baseline. Setting it to 10 times the baseline magnifies the pattern: higher values of v yield greater pro-cyclicality. The same holds true for the demand shock experiment: when χ^j is increased, higher v is associated with a larger response of output to the shock.

Summing up, the impact of higher capital requirements on pro-cyclicality is virtuous under the baseline parameterisation of our model. However, it depends on the type of shock considered, and it is also somewhat sensitive to the model parameterisation. More work is needed on this issue.

Next, we assess the effect of higher capital requirements on the steady-state values of the main economic variables. Figure 6 reports some key results from this exercise. In each panel, values of v ranging between 9 and 15 percent are measured on the horizontal axis. The figure offers several interesting insights.

First, output decreases monotonically as v is increased (panel A). This result appears intuitive: higher capital requirements should make the economy more stable, but at a cost, along an ideal efficiency/stability trade-off. Second, the decline in output is modest: the steady-state level of output under $v=15$ percent would be only 0.2 percent lower than under the baseline $v=7$ percent. However, this effect must be qualified. To begin with, the decline in output is concomitant with an increase in the equilibrium number of hours worked: to prevent consumption from falling, workers choose to work more (panel B). This implies that a broader measure of welfare would signal that the cost of higher capital requirements is greater than suggested by simply looking at traditional measures, such as GDP and its components. In addition, the decline in output reflects divergent patterns for its components. Specifically, the steady-state level of consumption decreases monotonically with v, while investment increases. In turn the increase in investment is driven by an increase in loans, which could be model-specific and not preferable to alternative modeling choices available to the banking sector. Third, in the version of the model used here the higher steady-state v translates into a decline in the depreciation rate of bank capital, δ_b. This amounts to assuming that banks make up for the extra cost by increasing efficiency. However, in practice banks might also react by shifting part of the cost to their clients, e.g. by increasing loan rates, or by reducing dividends. In this case the output loss due to stiffer requirements will be greater. Preliminary estimates conducted with a version of the model in which these alternative channels are allowed to operate confirm that the steady-state output loss may be larger, but still relatively modest on

average.[27] Summing up, output and also the aggregate welfare of households and entrepreneurs fall monotonically as ν is increased; the estimated decline is modest, but our caveats suggest that the effect could be underestimated.[28]

These results have some policy implications relating to the proposals to increase capital requirements. On the pro side, higher capital requirements increase the ability of the banking system to withstand shocks.[29] However, their effectiveness in terms of attenuating pro-cyclicality is dubious: they may either decrease or increase the sensitivity of bank variables and the key macro variables to the business cycle, depending on the nature of the shock. On the down side, higher requirements could reduce aggregate welfare. Overall, with the usual caveats, these results suggest that limiting pro-cyclicality may perhaps best be pursued by policy options other than higher capital requirements.

Figure 6 - Increasing ν : effect on the steady-state levels of key economic variables
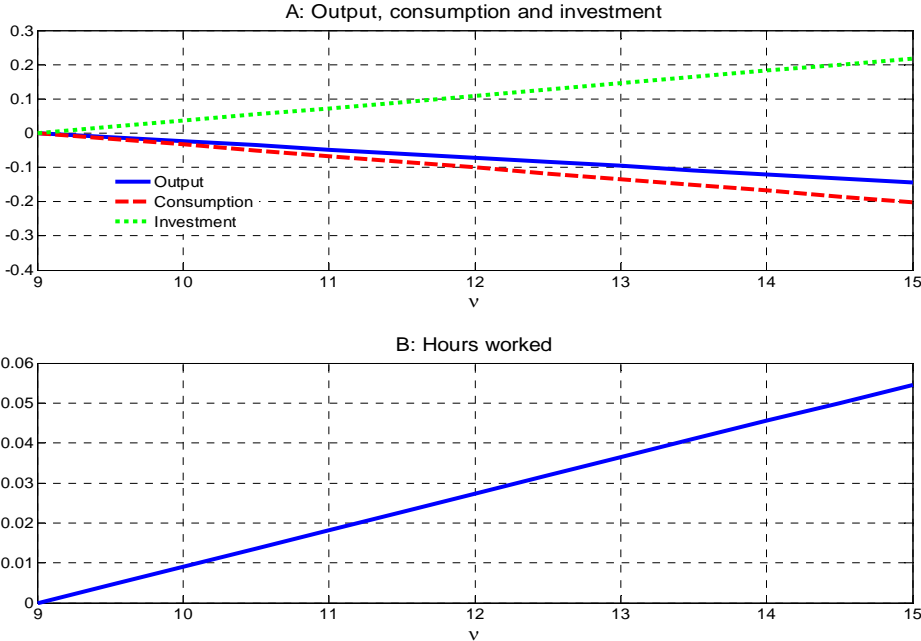
Note: The graphs reports the percentage deviation from the steady state of the variables as ν is gradually increased from the initial value of nine percent. ν is measured on the horizontal axis. For output, consumption and investment, the deviations are expressed in annualised terms.

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[27]   See Angelini and Gerali (2010). See also Macroeconomic assessment group (2010) and Basel Committee (2010).

[28]   The lower welfare caused by higher capital requirements at the aggregate level stems from opposite effects on savers and borrowers. In terms of consumption equivalents (a measure used in the literature when comparing welfare across different steady states), savers should be compensated when increasing capital requirements while borrowers (both households and entrepreneurs) would be willing to pay to move to a steady state with a higher capital requirement.

[29] It must be remarked that in our framework banks and firms never default in equilibrium. Thus, we do not consider the fact that higher capital requirements reduce banks' probability of failure, an important factor of stabilisation.

5. Technical Discussion

The results derived thus far are relatively clear-cut and reasonably robust to a series of alternative assumptions about some model features and parameters. However, the uncertainty surrounding our estimates is certainly much greater than is the case with many other macroeconometric studies. What follows is a list of technical issues to which this observation applies or that could lead us to suspect a bias of some sort in our baseline estimates, and, in particular, in one of our key results (that the extra pro-cyclicality injected by Basel II is small).

(i) The model used in the present paper belongs to a family that precludes firm and bank defaults in equilibrium. Models in this family include Kyiotaki and Moore (1997), and more recently Iacoviello (2005) and Iacoviello and Neri (2009). Alternative models in which defaults can and do happen are Bernanke, Gertler and Gilchrist (1999) and Christiano, Motto and Rostagno (2007). It remains to be seen whether a different macroeconomic environment could alter our conclusions.

(ii) The model does not distinguish between required capital and buffers held voluntarily by banks. As discussed in sections 3.2 and 4.1.1, there are reasons to believe that banks would at least in part offset the extra pro-cyclicality induced by Basel II via such buffers.

(iii) In section 4.2 we saw that as ν is increased, investment and lending also increase. This effect could be model-specific and not robust to alternative choices for modeling the banking sector.

(iv) Banks' lending rates incorporate changes in the capital requirement (via equation 2), but they do not take account of potential changes in the idiosyncratic riskiness of households and firms. In principle, rates on loans to firms, say, should increase in response to an increase in the riskiness of firms (measured by w^F).

(v) In the current version of our estimated model, the steady-state ratio of investment to output (defined as consumption plus investment) is around 13 percent, compared to a real-world average of 26 percent in the euro area. This is likely to induce an underestimate of true effects, because in our environment Basel II works primarily through its effect on investment.

(vi) In our model bank capital has an implicit cost, given by the depreciation rate, but no explicit cost. Under alternative modeling choices, capital can be made a choice variable for banks and be assigned an explicit cost, possibly varying through the cycle.

Other things being equal, features (iii) to (vi) point to a potential downward bias in our estimate of the pro-cyclical effect of Basel II, whereas (ii) points in the opposite direction. The sign of the net effect is hard to tell.

6. The policy debate on countercyclical tools

The results produced above may help financial regulators in giving operational content to the recommendations that the G20 set out in April 2009. First, our analysis does confirm that to some extent the transition to Basel II has heightened the effect of banks' capital on the dynamics of lending and ultimately on the real economy, but the findings also suggest that the magnitude of this effect may well have been overemphasised. Nevertheless, they are consistent with the view that some correction to the current prudential framework is warranted, and that policymakers should seek to eliminate the potential pro-cyclical effects of capital regulation. Our analysis further suggests that this additional safeguard would be obtained more appropriately by countercyclical buffers than by a simple, one-off increase in capital requirements.

Our model cannot distinguish among the various proposals, which are too complex and detailed to be shaped in our simplified framework, and accordingly here we first review the main proposals for introducing countercyclical devices within and in addition to the Basel II framework, commenting on their pros and cons. This is followed by a discussion of the countercyclical toolkit proposed by the BCBS (2009).

6.1 Review of the main proposals

6.1.1 Smoothing the inputs of the capital function

Specification of more binding rules on how banks should estimate risk parameters. - Generally, in most rating systems, the PDs are assigned in a two-stage process. First, a rating is assigned to the counterparty; next, a PD is assigned to an individual rating grade. Cyclicality can result from one or both of two processes (i) migrations (i.e. individual counterparties are assigned better or worse ratings as the cycle improves or deteriorates), and (ii) recalibration of the mapping from rating grade to PDs (i.e. counterparties in a given rating grade will be assigned a different PD).

In PIT rating systems the role of factor (ii) will typically be negligible, whereas factor (i) will be important: in a downturn a large number of borrowers will migrate to worse grades, resulting in higher capital requirements (and vice versa in an expansion). By contrast, in TTC rating systems migrations to different rating grades are rare and their role as a driver of pro-cyclicality tends to be negligible. In TTC systems some volatility of capital requirements can still derive from factor (ii). Therefore, compulsory adoption of TTC systems can be seen as a straightforward way to reduce the pro-cyclicality induced by capital regulation.[30]

6.1.2 Strengthening stress tests

Another option, which can go together with more TTC ratings, is to strengthen Pillar II provisions under Basel II, in particular stress tests. Bank supervisors are already responsible for assessing capital adequacy in the light of cyclical conditions and macro-prudential

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[30] Basel II expresses a preference for TTC systems, but it does not make them compulsory. Indeed, in Europe, most banks have adopted hybrid solutions, including both PIT and TTC components.

concerns. Pillar II gives supervisors the discretion to require banks to increase capital resources above the Pillar I minimum. While not intended exclusively for the purpose,[31] Pillar II rules have been designed in part to reduce cyclicality (this is the reason why stress tests should at least consider the impact of a recession on capital adequacy). Banks can be required, for instance, to run stress tests based on common recessionary scenarios set by supervisors and adjust their capital buffers according to the results of such simulations.

6.1.3 Adjusting the capital function

Time-varying confidence levels. - Kashyap and Stein (2004) note that the new prudential discipline aims to keep the probability of default of any bank below a given threshold, regardless of economic conditions. The time invariance of the threshold implies that in recession the objective of reducing the probability that banks will default is over-weighted and that keeping sufficient credit flows to the economy is under-weighted (and vice versa during expansions). Kashyap and Stein (2004) conclude that a policymaker who cares about both objectives could adopt confidence intervals that change over the business cycle. This position is supported by Repullo and Suarez (2008), who show that simple cyclical adjustments in the confidence level used to compute the Basel II capital requirements could significantly reduce pro-cyclicality.

Time-varying asset correlation. – Another option is the adjustment of the asset correlation parameter, which is either constant or dependent on PD levels for different asset classes. The correlation would be adjusted downwards in bad times, upwards in expansions. This approach appears consistent with the conceptual framework underlying Basel II, where co-movements in credit risk are driven by a single systematic risk (i.e. the business cycle) which is captured in the model through asset correlation.

6.1.4 Smoothing the output of the capital function

Adjustments based on autoregressive mechanisms. - Gordy and Howells (2006) propose to smooth the output of the capital requirements formula, arguing that this will reduce pro-cyclicality while preserving the informative value of PIT ratings. They discuss an autoregressive filter to be applied to the individual bank's capital requirement, so that shocks are absorbed into the regulatory minimum over several years rather than all at once.

Adjustments based on time-varying multipliers. – A second group of proposals would apply a non-bank-specific, time-varying multiplier to the output of the regulatory formulae. The multiplier would be greater than 1 in good times, less in bad. Gordy and Howells (2006) mention, as an example, a multiplier tied to a moving average of the aggregate default rate for commercial bank borrowers. Repullo and Suarez (2008) propose a multiplier based on the deviation of GDP growth from trend. Goodhart and Persaud (2008) propose to use credit growth. Himino (2009) proposes equity prices.

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[31] The role of the supervisory authorities in Pillar II is to ensure that banks have adequate capital to sustain all the risks of their business, including in crisis times, and to stimulate banks to develop and use better risk monitoring and management techniques. The purpose of Pillar III (market discipline) is to complement the minimum capital requirements (Pillar I) and the supervisory review process (Pillar II).

6.1.5 Buffers based on risk-sensitive conditioning variables

An alternative approach for dealing with cyclicality is to rely directly on risk-sensitive variables. CEBS (2009), for instance, proposes a mechanism for measuring the gap between banks' capital needs in recession and in normal times. Since the prime source of cyclicality in banks' rating models is the probability of default, CEBS proposes rescaling the banks' estimated PDs to incorporate recessionary conditions. In practice, the proposal is for a scaling factor that diminishes in recession and increases in expansionary phases, to multiply the current PD in the regulatory capital formula. The approach can be applied at the portfolio level (i.e. at the level of each asset class in the banking book). First, the PD of the portfolio at time (t) is calculated as the average of grade PDs weighted by the number of counterparties in each grade. The PD of the portfolio would obviously change over the cycle as the result of two distinct factors:

- transition of borrowers across grades (which is more pronounced in PIT-leaning rating systems);
- change of grade PD (which is more pronounced in TTC-leaning rating systems).

Then, a scaling factor can be computed as the ratio of the downturn PD and the current PD, which is close to 1 in a recession and assumes values greater than 1 in expansions. The final step is to adjust grade-PDs using the scaling factor and compute the buffer as the difference between the regulatory capital requirements based on the adjusted PDs and those based on the unadjusted PDs.

The key element of the CEBS proposal is that the requirement so obtained should serve as a benchmark for supervisors when assessing the adequacy of Pillar II buffers. In other words, the adjusted PDs would serve as a transparent way to identify worst-case capital needs and, thus, to define the adequate level of buffers.

6.1.6 Countercyclical provisioning

The proposals reviewed so far have all entailed mechanisms to build up capital buffers. Another way to accumulate resources in good times for in recession would be to modify loan-loss provisions.

The choice of the mechanism used for countercyclical provisioning is affected by accounting issues. In fact, current accounting standards allow banks to provision only at the very moment when losses are actually incurred. This can have a pro-cyclical effect, as bad loans accumulate during good times but losses tend to emerge in bad times.

One mechanism for correcting this pro-cyclical effect would be to align provisions with long-term expected losses. This proposal has been set out by IASB (2009), recommending that provisions should reflect the losses that banks estimate will be produced by a portfolio of loans over its entire life.

Another proposal has been put forward in the Turner Review (See FSA 2009a, 2009b). The proposal links provisions to the stock of outstanding loans. The ratio of provisions to total loans is derived from historical experience and designed to capture latent losses in the overall loan portfolio. To avoid over-provisioning, a cap would be set.

So far, however, the only practical example of countercyclical provisions is the Spanish system of dynamic (or 'statistical') provisioning. Spain's approach links provisions to banks' historical loan-loss experience. Each year, banks are required to charge their income statement specific provisions for incurred losses, plus generic provisions, based on historical credit losses. Generic provisions are an increasing function of the flow of new credit, as well as of the stock of outstanding loans (the parameters of this function are set by the regulator). In good years, credit losses are typically low, and generic provisions are larger than specific; thus, the difference between the two is added to the stock of provisions accumulated in previous years through the same mechanism. In recession years generic provisions will tend to be smaller than specific provisions, and the difference is covered by drawing on the accumulated stock. Spanish rules include upper and lower limits to the stock of general provisions, which have been set by the Banco de España taking account of the impact of past severe recessions.

6.2 Critical assessment of the proposals

The model used in this paper does not help select an ideal system. However, we believe that proper analysis of the pros and cons of the proposals will rule some approaches out.

Requiring banks to use TTC rating systems does not seem either feasible or desirable. As Gordy and Howells (2006) point out: i) TTC ratings would impair the comparability of the capital requirement over time and would make it difficult to infer changes in portfolio risk from changes in capital ratios; ii) they are poorly suited for internal pricing and risk-management purposes and may thus fail the 'use test' called for by Basel II, which envisages that risk estimates used for the calculation of capital requirements be effectively employed for internal risk management.

Reinforcing stress tests is certainly promising, but it may pose challenges in terms of international convergence of methods and approaches under Pillar II.

Conversely, the revision of the capital functions would be impracticable. The current calibration of the regulatory formulae is the outcome of a lengthy process intended to ensure consistent risk assessment across asset classes, so changing it would again require protracted quantitative analysis.[32] We also note that the proposals for time-varying capital functions, while appealing in principle, are hardly workable in practice insofar as they rely on supervisory authorities identifying the correct phase of the business cycle. In addition, as cycles differ across countries, a common recalibration would probably be inappropriate, and country-specific adjustments would be needed. This might reduce the meaningfulness of cross-country comparisons of banks' solvency positions and increase the discretion left to national authorities. Furthermore, for large cross-border players there could be substantial problems of implementation: it would not be obvious how the conditioning variable (credit expansion, equity prices, or other) should be defined, especially if host and home supervisors have different views[33] (Borio et al. 2001).

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[32] On the process that eventually led to the calibration of Basel II, see Cannata (2007).

[33] For instance, the host authority might wish to impose higher capital ratios on banks operating in their country because of local concerns, while the home supervisory might find a higher capital ratio at the consolidated level unwarranted where local developments have only a small effect on the overall risk profile.

Similar criticisms apply to the proposal for adjusting the capital requirements based on time-varying multipliers. In turn, each variant for the definition of the multiplier has specific advantages and problems. First of all, market variables such as equity prices or CDS spreads are not necessarily robust indicators of credit cycles, especially for banks that are mainly active in retail and small-business lending. Moreover, establishing a link between capital requirements and forward-looking measures of economic conditions, such as equity prices, would make the requirement heavily dependent on market volatility.[34] Using macroeconomic indicators (GDP growth) would have drawbacks due to publication delays and revisions.

Smoothing the output of the capital function through autoregressive mechanisms may create perverse incentives. A weak bank may be encouraged to increase portfolio risk rapidly (gambling for resurrection) because the capital requirement would adjust only slowly. Moreover, the calibration of adjustment speed would pose practical challenges. In fact, the timing of capital restoration after a crisis would depend largely on the choice of this parameter, which may be difficult to estimate.

More importantly, most of the variants discussed so far share one major drawback: because they define aggregate, system-wide adjustments, they cannot capture the specific features of individual banks and may thus introduce distortions and tilt the playing field. A bank with declining loans should not be required to increase capital by a rule linking capital requirements to aggregate credit growth. Furthermore, the proposed adjustments would fail to discriminate between banks with TTC and PIT approaches. Reliance on TTC estimates would thus be discouraged, as TTC banks would in any case be required to build up buffers just like banks using PIT measures of credit risk.

The CEBS proposal does not suffer from this shortcoming: it is bank-specific; it is based on risk-sensitive conditioning variables and therefore meets the incentive structure provided for by Basel II (banks using TTC should be required to hold smaller buffers than those adopting PIT systems, in which capital requirements fluctuate more markedly over the cycle). These features reduce the risk of regulatory arbitrage, which is likely where non-risk-sensitive adjustments are applied. In addition, there is no need for supervisors to define recessions/expansions, since PD fluctuations, hence the dynamics of the scaling factor, approximate the evolution of the business cycle. More generally, the approach does not require any calibration of the buffer; in fact, each bank would be required to hold a buffer consistent with the cyclicality of its capital requirements: if cyclicality is a small problem, the solution would be small, and conversely if it is serious.

While we find the proposal sensible, some issues do need to be addressed. First, this approach attenuates the pro-cyclicality of capital regulation, but does not lead to truly counter-cyclical capital buffers. In fact, the buffers will move through the cycle to compensate for the fluctuations of risk-sensitive capital requirements, bringing the Basel II framework close to Basel I. If counter-cyclicality were deemed desirable, other tools would be needed, to allow the freeing of capital in recessions. Second, the proposal might lead to wrong outcomes for banks that experienced significant structural changes in portfolio composition – e.g. through M&As – and would face requirements based on past measures of risk that are no longer significant. This could be amended by leaving some flexibility in application, allowing banks to discuss with supervisors possible structural breaks in their time-series and thus the need to

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[34] Other financial variables (such as spreads on credit default swaps) are likely to suffer from similar problems.

change the value of the downturn-PDs, if deemed appropriate. Third, CEBS suggests applying the mechanism under Pillar II, the supervisory review process. This means that supervisors would enjoy some degree of freedom in deciding whether and how to take corrective actions where the buffers are below the required level. Admittedly, the cross-country differences in applying Basel II are significant and may lead to concerns about an uneven playing field. But if consistent enforcement of the mechanism under Pillar II does not look feasible, it could always be considered as a true capital requirement under Pillar I. In this case, banks would continue to use their internal estimates for borrower selection and pricing, but they would be required to use the scaling factor mechanism for calculating the regulatory capital charge. This may weaken the use test, but it would preserve the informative value of PIT rating systems.

As to countercyclical provisioning, it does not directly amend the pro-cyclicality of capital requirements, but it does contribute to the build-up of buffers in good times. The technical specification of the instrument is crucial, though. For instance, the proposal put forward in the IASB staff paper would be based on banks' internal estimates of expected losses. Such specification might be pro-cyclical, as it would generate more frequent changes in provisioning for banks relying on PIT estimates of credit risk: for those banks, provisions would indeed increase during downturns, thus restraining lending capacity, while their low levels during upswings would contribute to sustained profits and lending booms.

The Spanish dynamic provisioning mechanism would not appear to suffer from these drawbacks, as it is based on statistical measures of loan losses and does not depend on the cyclical sensitivity of banks' internal models. One potential problem with this system is that it blurs the distinction between expected and unexpected losses, which could clash with accounting rules (Burroni et al, 2009).

6.3 The proposals of the Basel Committee

Where does the above discussion leave us? As we have seen, most proposals have pros and cons, which may help explain why no clear 'winner' has emerged. So it is not surprising that the Basel Committee (2009, 2010a) opted for a set of tools that should ideally complement one another. Specifically, the December proposal includes measures for: 1) mitigating the cyclicality of the capital requirement; 2) promoting more forward-looking provisions; 3) inducing banks to conserve capital; 4) achieving the macroprudential goal of protecting the banking sector from excess credit growth.

To mitigate the volatility of minimum required capital, the Committee aims to develop a set of supervisory tools – including PD adjustments *à la* CEBS – to assess the adequacy of banks' capital buffers in relation to their various ratings methodologies. Stronger provisioning practices would result from revised accounting rules that permit an expected-loss approach and that are not limited to incurred losses. The Basel Committee then proposes a capital conservation buffer, based on mechanisms that constrain dividend distribution (or bonus payments) in order to meet a predefined solvency target. The farther the actual solvency level is from the target, the tougher the limits on payout ratios. Finally, the building-up of a macroprudential buffer is pursued through a regime that would adjust the capital buffer range when there are signs that the economy is overheating (for instance, if aggregate credit is excessive with respect to historic trends). This will ensure that all banks build up countercyclical capital buffers in times of euphoria, to draw on when the authorities – at their

discretion – announce that bad times are approaching and bring the capital buffer back down to normal levels.

All the proposals are still under development, but they seem to go in the right direction. However, in our view some important issues need to be properly addressed in order to make the countercyclical package effective and avoid undesired consequences.

First, defining the supervisory tools for dealing with the cyclicality of the minimum capital requirement should be a top priority. We believe that the capital conservation buffer and the macroprudential buffer – "one-size-fits-all" measures – may have perverse effects unless they are properly complemented by a device for smoothing the fluctuations of the regulatory minimum. Without such a device, in good times the banks using TTC ratings would be required to hold higher buffers than those using PIT, endangering the functioning of the whole countercyclical toolkit.

We are also concerned that the capital conservation buffer – as currently designed – appears to be chiefly a tool for defining prompt corrective supervisory actions and does not seem to deliver any countercyclical benefit. In that respect, the countercyclical and the capital conservation buffers might well be packed into a single tool, with a time dynamics linked to the evolution of aggregate credit, penalties in terms of dividend restrictions and clear mechanisms for allowing the buffers to be almost entirely depleted when necessary.

Finally, concerning provisions, it is important to recognise that the concept of expected losses used thus far is probably too narrow, and that provisions should be accumulated vis-à-vis a broader one. The Spanish system proved effective in the current crisis – an important advantage relative to other similar proposals, which have not been applied or tested in practice – and would be a valuable option. However, in view of the concerns expressed by accounting standard setters, the Basel Committee developed an approach that hinges on their proposals. This sounds like a pragmatic way forward, but great care needs to be taken with the technical specification of the instrument.

7. Conclusions

In the aftermath of the current financial crisis, a consensus has emerged that the Basel II capital rules need to be amended. Widely discussed proposals, which are to be implemented once the crisis is over, focus on the level and dynamics of bank capital. Great emphasis is placed on the need to reduce the pro-cyclical effects of the new regulation, although there is still much uncertainty as to their practical importance.

This paper has moved from the consideration that the current policy debate lacks a consistent way of measuring the benefits and costs of the changes proposed. We have addressed the problem of regulation with a macroeconomic model, which allows us to examine the functioning and possible shortcomings of risk-based capital regulation and potential policy measures aiming at mitigating pro-cyclicality. Our results are relatively clear-cut and reasonably robust when set against a series of alternative assumptions on some model features and parameters. At the same time, it must be openly acknowledged that the uncertainty surrounding our estimates is considerably greater than in most other macroeconometric work, owing in part to the limitations of our DSGE framework, which models the financial sector in

a very simplified fashion. Given this major caveat, the answers to the four questions raised in the introduction must accordingly be read with caution.

First, our results confirm that Basel II can increase the pro-cyclicality of the banking system, by comparison with Basel I. Our simulations suggest that following a technology shock (a key driver of macroeconomic fluctuations in our model), the maximum deviation of output from steady state is 0.64 percentage points under the Basel II framework, compared with 0.62 under Basel I – a negligible difference. The effect works mainly through investment, where the difference is more pronounced but still small. A monetary policy shock yields an even smaller differential effect. The robustness of this result was assessed by changing key model parameters within reasonable ranges. This can increase the difference somewhat, to a high of 0.3 percentage points in maximum output response. Overall, subject to the caveats discussed in section 5, our results suggest that the extra effect induced by Basel II is modest. The same conclusion, and the same caveats, apply to the comparison between the PIT and the TTC approaches established by Basel II.

Second, we find that higher capital requirements (often advocated in the recent debate, although seldom motivated on grounds of reducing pro-cyclicality) may attenuate the pro-cyclical effects of capital regulation, but their effect depends on the type of shock affecting the economy. In a Basel II regime, the reaction of output to a technology shock or a demand shock is attenuated by higher capital requirements, but under a monetary policy shock this result vanishes. Overall, our results provide only weak support for this measure to counteract pro-cyclicality.

Third, there does appear to be room for a countercyclical regulatory policy. Simulation conducted with the model augmented with a simple regulatory reaction function that increases capital requirements during periods of buoyant growth and reduces them in downturns, can easily offset the pro-cyclicality induced by the switch to Basel II and could even bring it below the Basel I benchmark.

Would such a policy of countercyclical capital (or provisions) be spontaneously implemented by banks via voluntary accumulation during booms and depletion in recessions? As above, our results suggest that the answer depends on the type of shock posited. In a Basel II regime, a policy of countercyclical buffering is beneficial for banks (it increases profits) in the event of a technology or a demand shock; but it reduces profits under a monetary policy shock. Thus, our analysis provides only partial support for the argument that under the new Basel II rules banks will find it optimal to offset the additional pro-cyclicality with voluntary capital buffers. Our results suggest that in some cases the countercyclical management of capital requirements enforced by a regulator could be beneficial. The practical application of this policy needs not be discretionary; that is, it could be rule-based and not require regular board meetings.

Fourth, we address the issue of the macroeconomic cost (in GDP growth) of policies aiming at mitigating pro-cyclicality. Our findings suggest that a permanent increase in the capital requirement would have negative consequences on welfare. The negative effect on steady-state output would be accompanied by an increase in the number of hours worked, so that, in terms of welfare, the loss could be larger than is suggested by looking at output alone. By contrast, the adoption of a countercyclical capital policy would have no effect on the steady state of the model, hence no macroeconomic cost (in terms of steady-state levels of the

variables). This conclusion provides further support for the view that pro-cyclicality should be attenuated by a countercyclical capital policy.

The thesis that capital (or provisions) should be adjusted in countercyclical fashion is the common denominator to many of the proposals currently under discussion. Our model is unable to provide guidance on the practical implementation of such a policy, as it cannot discriminate among the various important technical differences characterising the proposals. However, it serves to set the stage for our critical review of the proposals, and it does provide some guidance as to the strength of the measures.

In summary, our review of the debate prompts several considerations. The Basel II framework has desirable features that should not be discarded. The risk of pro-cyclicality should be contained by means of a package including countercyclical capital buffers and dynamic provisioning. In our view, the proposals recently advanced by the Basel Committee represent a reasonable option for addressing pro-cyclicality, but they may require some adjustment in order to avoid unintended consequences.

First, greater attention should be paid to the tools for attenuating the cyclicality of PIT rating systems, as the first, essential element in any countercyclical package. Second, all buffers should be genuinely countercyclical. That is, banks should be allowed to draw on them in bad times. In that respect, the time dynamics of the capital conservation buffer is still undefined, which markets may interpret as an attempt by regulators to introduce a new (albeit softer) minimum requirement. It is also crucial to complete the work on dynamic provisioning, developing methods that ensure that provisions are aligned to expected losses on a truly through-the-cycle basis.

A final comment on the trade-off between rules and discretion: we pointed out that automatic mechanisms may be difficult to calibrate and could suffer from difficulty in obtaining precise macroeconomic forecasts. Further, their rigidity may prove unsuitable for specific contingencies. On the other hand, discretionary judgement could put supervisors under strong political pressure, making any countercyclical tool inter-temporally inconsistent and therefore not credible. The Basel Committee has opted for measures that leave national authorities a 'constrained discretion'. This is probably reasonable, but it should be accompanied by rigorous peer review that assesses and removes unwarranted national differences in implementation.

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Appendix 1: The calibration of risk-weighted assets

The potential pro-cyclicality of Basel II depends on the cyclical behaviour of the risk parameters, particularly probability of default (PD) and loss given default (LGD), which affect the risk weights via the regulatory formulae.

In the setting of the model used in this paper, the parameter χ in equation 6 represents the sensitivity of the Basel II risk weights to macroeconomic conditions (i.e. the degree of cyclicality of the Basel II capital requirements). Ideally, the calibration of χ should be based on the time series of the risk weights calculated according to the Basel II rules. Unfortunately, in most countries the new prudential framework has been applied only in 2008 – if at all – so no time series is yet available.

In principle, to analyse pro-cyclicality we could simulate our model for different values of χ and check the feedback effect from the financial sector to the real economy in each case. However, this methodology would not solve the issue of the *actual* degree of pro-cyclicality of the Basel II framework.

Without no pretension to providing the final answer, in order to inquire into the *true* pro-cyclicality of Basel II, we estimate χ starting from available proxies and exploiting the set of regulatory formulae provided for by the accord (See Basel Committee 2004). In particular, we proceeded as follows. First, we used US data on the delinquency rates on loans to households and firms as proxies for the probability of default.[35] Second, we inputted these time series into the Basel II capital requirements formulae, and using realistic assumptions concerning the other key parameters of the formula (LGD, firm size, and the maturity of the loans) we estimated the time series of the risk weights w_t^F, w_t^H. This allows us to simulate the dynamics of risk weights for advanced IRB (AIRB) banks, under the hypothesis that PD is the only source of cyclicality of the risk weights. This is obviously an approximation, but a realistic one since AIRB banks are required to estimate downturn LGDs. Finally, we estimated equation 6 in the paper using the time series for risk-weighted assets.

The second step is obviously more difficult, since it requires some judgment on the most appropriate figures for the key risk parameters. As mentioned, for the PDs we used the delinquency rates for US loans. In other words, we assumed that the behaviour of PDs goes hand in hand with that of credit losses. This is clearly an approximation – as forward-looking PDs do not necessarily exactly match backward-looking historical losses – but a reasonable one, as one would expect PDs to be closely correlated with actual credit losses in the long term.

Since we have separate time series for firm and household delinquency rates, we applied the method described above to each category.

For non-financial firms we used the corporate regulatory function with no size adjustment. This is equivalent to assuming that firms have sales of at least €50 million. This also means

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[35]   Delinquency rates are provided by the Federal Reserve Board over the period 1991-2007 on a quarterly basis; they are annualised and seasonally adjusted. For households we used delinquency rates on single-family residential mortgages from banks ranked 1st to 100th in size (by assets). For firms we used delinquency rates on business loans from banks ranked 1st to 100th in size (by assets). To the best of our knowledge comparable data for either the EU or the euro area are not available.

that we assumed closer asset correlation and thus greater cyclicality than in an SME portfolio; to some extent we are overestimating cyclicality. The LGD is set at 40 percent, consistently with the figures reported in Basel Committee (2006). The maturity of the loans was set at 2.5 years, as in the standardised approach.

For households, since data refer to mortgages, we used the residential mortgage function, with LGD equal to 20 percent, following QIS5. Both functions include the 1.06 scaling factor. Using the regulatory formulae, we obtained the capital requirements (as a percentage of the exposure at default), which are then multiplied by 12.5 in order to obtain risk weights .

The results of the regression estimated using these data are reported in the table below. The regression estimates the log-linear version of equation 6, since it is exactly in this form that it enters the model:

$$\hat{w}_t^i = (1 - \rho_i)\chi_i\left(\log \hat{Y}_t - \log \hat{Y}_{t-4}\right) + \rho_i\hat{w}_{t-1}^i$$

where a hat denotes percentage deviations from steady state and the term in brackets measures output growth.

Table A1. Sensitivity of weights to cyclical conditions

Dependent variable	ρ	χ	R^2
Business loans	0.92 (0.03)	-14 (4.6)	0.97
Residential mortgages	0.94 (0.04)	-10 (8)	0.89

Note: Nonlinear least squares. In the case of households standard errors are corrected for heteroscedasticity and autocorrelation of residuals of order 2. Sample period: 1991:Q1 to 2007:Q4. For households we used delinquency rates on single-family residential mortgages from banks ranked 1st to 100th in size by assets. For firms we used delinquency rates on business loans from the 100 largest banks by assets. Data are taken from *Federal Reserve Board* (http://www.federalreserve.gov/releases/chargeoff/deltop100sa.htm). Cyclical conditions are measured by year-on-year changes in real GDP (http://research.stlouisfed.org/fred2/series/GDPC96?cid =106). All data are seasonally adjusted.