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Abstract

We assess the long-term economic impact of the new regulatory standards (the Basel III reform), answering the following questions. (1) What is the impact of the reform on long-term economic performance? (2) What is the impact of the reform on economic fluctuations? (3) What is the impact of the adoption of countercyclical capital buffers on economic fluctuations? The main results are the following. (1) Each percentage point increase in the capital ratio causes a median 0.09 percent decline in the level of steady state output, relative to the baseline. The impact of the new liquidity regulation is of a similar order of magnitude, at 0.08 percent. This paper does not estimate the benefits of the new regulation in terms of reduced frequency and severity of financial crisis, analysed in Basel Committee on Banking Supervision (BCBS, 2010b). (2) The reform should dampen output volatility; the magnitude of the effect is heterogeneous across models; the median effect is modest. (3) The adoption of countercyclical capital buffers could have a more sizeable dampening effect on output volatility. These conclusions are fully consistent with those of reports by the Long-term Economic Impact group (BCBS, 2010b) and Macro Assessment Group (MAG, 2010b).

JEL classification: E44, E61, G21.

Keywords: Basel III, countercyclical capital buffers, financial (in)stability, procyclicality, macroprudential.

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Contents

1. Introduction[1]

This study presents an assessment of the long-term economic costs of the new rules introducing tighter capital and liquidity requirements proposed by the Basel Committee on Banking Supervision (see BCBS 2009a and 2009b) – commonly referred to as the Basel III reform package. Specifically, the paper addresses the following key questions. What is the impact of higher capital requirements and tighter liquidity regulation on economic fluctuations? The analysis presented in the paper is fully consistent with those of the Long-term Economic Impact (LEI) group (BCBS (2010b)) and the Macroeconomic Assessment Group (MAG (2010a) and MAG (2010b)). It is worth emphasizing that our focus is on the costs of the new regulation, as our methodology is not intended to capture the benefits (except under a very narrow definition of benefits, in terms of reduced output volatility, which we discuss below). The broader objective of evaluating the gross benefits of the new regulation and – using our estimates of the costs – its net benefits, is provided in the LEI report (BCBS, 2010b).

Our methodology mainly relies on counterfactual experiments conducted with macroeconometric models. In its essence, the idea is to "map" a highly stylized version of the new regulatory scenario (tighter capital and liquidity requirements, countercyclical capital buffers) into model inputs, parameters and features, and study the resulting steady state values and volatility of key macroeconomic variables.

Most models used are of the dynamic (stochastic) general equilibrium family (D(S)GE). This class of models was used because it is the only one allowing counterfactual experiments with policy scenarios to be conducted in a conceptually consistent manner, and capable of tackling questions (2) and (3). However, following a "diversification" approach, a limited number of alternative models (semi-structural and vector error correction models (VECM)) were also used to answer question (1) – models in this class being less suited to addressing the remaining two questions. Another approach to address question (1) was based on welfare, which is arguably a more comprehensive measure than output. Estimates were obtained from

[1] We are grateful to Cesaire Meh (Bank of Canada) and David Aikman (Bank of England) for providing the estimates for USA/Canada and the United Kingdom presented in Section 5.1, and to Ryou Katou (Bank of Japan) for providing the results for Japan presented in Section 5.3. We thank Claudio Borio and N. Esho for useful comments and suggestions. The views expressed in the paper are our own and do not necessarily reflect those of the institutions for which we work, the Basel Committee on Banking Supervision or the Financial Stability Board.

simple formulas derived from a theoretically microfounded model, expressing the welfare loss caused by the higher capital requirement in terms of percentage deviation of consumption from steady state, or directly from welfare computed in some of the models.

The main results of this study are the following. (1) Each percentage point increase in the capital ratio translates into a 0.09 percent loss in the level of steady state output, relative to the baseline (median across the point estimates of the available models). Similar results are obtained using the welfare-based measures. The median impact of meeting the Net Stable Funding Ratio (NSFR) is of a similar order of magnitude, at 0.08 percent. (2) Tighter prudential rules induce a decline in output volatility, whose magnitude is heterogeneous across models; the median effect is modest. (3) A prudential rule that increases the capital requirement when the credit/output ratio rises seems capable of reducing output variance in a sizeable way.

These results are subject to a series of important methodological caveats, which are discussed at length in the following sections. We feel that two such caveats should be mentioned at the outset. The first concerns the new liquidity regulation. The estimates of its effect on economic growth are particularly uncertain, due to data gaps that made it very difficult to translate the reform into model inputs. The second caveat concerns the cross-country dimension of the results. Model-based results are available for the euro area, the United States, Canada, Japan, Italy and the UK; welfare-based results are available for a broader set of individual countries. However, in our view the relatively high degree of uncertainty surrounding the estimates does not allow us to fully assess the existence of national heterogeneities. In interpreting the results, we emphasize median and average values of the effects – obtained by pooling the estimates from the various models/countries – and their dispersion. We believe that inference at the national level can best be done by looking at the current position of each country in terms of capital and liquidity adequacy; assessing the distance of this position from full compliance, as defined in the new regulatory scenarios; and then using our results to estimate the related cost. Estimates of this distance (or "capital/liquidity gap") for large international banks have recently been made available by the Quantitative Impact Study (QIS), conducted by the Basel Committee (BCBS, 2010c).

2. The models

A list of the models and a summary of their key features is reported in Table 1.[2] The choice of the suite of models was mainly dictated by two criteria. First, the models must be able to consider the effect of the new regulations in the long-run, taken to mean the steady state of the model. That is, the model must have a well-defined steady state, which is affected by the new requirements. This excludes models that assume a ‘Modigliani-Miller’ view of banks, in which banks are merely a ‘veil’, as in those models the stability of the financial system is simply not an issue to be concerned about. Second, the model’s new steady state must be straightforward to compute. The first criterion excluded most reduced form approaches, in which the steady state equilibrium remains unaffected by prudential policies (eg the vector autoregression (VAR) approach used by MAG (2010a); after a regime shift, these models by design return to the original steady state), whereas the second excludes large-scale models (eg most of the semi-structural models used in MAG (2010a).

The selected models differ in many respects. First, they refer to different countries or areas. Second, some are almost fully estimated, whereas others are largely or entirely calibrated (the value of the coefficients are taken from unrelated, generally microeconomic, studies casting light on specific parameters). Finally, and more importantly for our purposes, some models explicitly feature a banking sector and a role for bank capital and/or liquidity, while others do not. Specifically, eight models feature bank capital, six feature bank liquidity;[3] only five feature both bank capital and bank liquidity. Bank profitability is endogenous in four models, which take into account endogenous changes in banks’ net margins deriving from the new rules.

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2 Most of these models were also used to contribute to MAG (2010a,b), besides BCBS (2010b).

3 The two models employed by Vlcek for the US and the euro area exhibit liquidity requirements as an exogenously determined share of banks’ assets to be held in government bonds with lower but risk-free yield. The model by Motto and Rostagno for the euro area introduces liquidity as an endogenously determined fraction of assets via a production function approach in which excess liquidity is a factor of production for deposits. In the model *(5)* used by Clerc and developed by Dellas, Diba and Loisel (2010) for the US, liquidity is endogenously determined as the results of the maximization of the bank stock-market value. It reflects the funding side of banks and corresponds to the sum of excess reserves and the amount of securities issued by banks. The VECM model analysed by Gambacorta for the US considers a liquidity-to-deposits ratio, where liquidity is defined as the sum of cash and government bonds.

Table 1

Key features of the models used to assess the long-run economic impact of the new regulation[1]

Model	Model type	Reference country / Area	Estimated / Calibrated	Features bank capital	Features bank liquidity	Features endogenous profitability	Key lending spread[2]
(1) Gerali	DSGE	Euro area	estimated	yes	no	yes	$i_l - i_d$
(2) Vlček-Roger	DSGE	Euro area	calibrated	yes	yes	yes	$i_l - i_d$
(3) Roeger[3]	DSGE	Euro area	calibrated	yes	yes	no	$i_l - i_d$
(4) Motto-Rostagno	DSGE	Euro area	estimated	yes	yes	no	$i_l - i_d$
(5) Clerc	DSGE	Euro area	estimated	no	no	no	$i_l - i_d$
(6) Vlček-Roger	DSGE	USA	calibrated	yes	yes	yes	$i_l - i_d$
(7) Van den Heuvel	DGE	USA	calibrated	yes	no	no	$i_l - i_d$ $i_e - i_d$
(8) Cúrdia	DSGE	USA	estimated	no	no	no	$i_l - i_d$
(9) Clerc	DSGE	USA	calibrated	no	yes	no	$i_l - i_d$
(10) Meh	DSGE	USA/Canada	calibrated	yes	no	no	$i_l - i_d$
(11) Locarno	Semi-structural	Italy	estimated	no	no	no	$i_l - i_d$ $i_b - i_d$
(12) Bank of England	Semi-structural	UK	estimated	no	no	no	*n.a.*
(13) Gambacorta	VECM	USA	estimated	yes	yes	yes	$i_l - i_m$

[1] Where available, the references for the models are in the reference section, under the name of the authors listed in the first column. [2] i_l: interest rate on loans to firms; i_b: interest rate on long-term bonds; i_d: interest rate bank deposits; i_e: return on bank equity; i_m: monetary policy rate. [3] Model calibrated based on eight euro-area countries.

Sources: see references.

In general, capital and liquidity regulation affect economic activity via an increase in the cost of bank intermediation. More specifically, for given assets, banks must hold more capital, ie they must deleverage.[4] If the required return on equity and cost of bank debt do not adjust, then banks will increase lending spreads, to compensate for the higher cost of funding. Within the models featuring neither capital nor liquidity, the outcome is assumed to be an increase in bank lending spreads. In the models in which bank capital and/or liquidity are explicitly

[4] As noted in MAG (2010a), banks can issue new equity and/or increase retained earnings by reducing dividend payments, increasing operating efficiency, raising average margins between borrowing and lending rates and increasing non-interest income. They can also reduce risk-weighted assets, by cutting the overall size of their portfolios of loan and/or non-loan assets, or by shifting the composition of portfolios towards less risky assets.

modelled, the increase in lending spreads occurs endogenously as one response to the new regulation (albeit not the only possibility). Due to imperfect substitutability between bank credit and other forms of market financing (such as bonds), this leads to lower investment, which then affects employment and output.[5] All the models, except those that explicitly feature bank profitability, imply that that banks' return on equity (ROE) remains constant in the long term. If bank profitability is allowed to fall, the estimated increase in the spread is lower, and so is the impact on economic activity. This means that the estimated impact of tighter regulation on output represents an upper bound.

Most of the models used in the simulations belong to the last generation of the Dynamic Stochastic General Equilibrium (DSGE) family, in which banks' balance sheets and credit markets are modelled explicitly. They provide a unified framework to analyze how changes in capital and liquidity requirements affect banking conditions (spreads and lending) and ultimately output. Furthermore, DSGE models are virtually the only framework allowing counterfactual experiments with policy scenarios to be conducted in a conceptually consistent manner. As agents' expectations are explicitly modelled, so is their reaction to the simulated policy change. A third advantage of DSGE models is that it is generally possible to study the effect of the policy changes not only on the steady state values of the key macroeconomic variables, but also on their long-term variability.

DSGE models have disadvantages too. Many of the available models are fully or partially calibrated, since estimation is often daunting. As a result, quantitative results might be questionable. While well-established within the scientific and the central banking community, the average model in this class still falls short of "full realism". Furthermore, even the more complete DSGE models used in this paper miss several empirically important aspects, such as endogenous risk and defaults.

In a few cases it has been possible to use models that we loosely label "semi-structural", regularly used by central banks and other economic agencies for forecasting and policy analysis. Their main advantages are reliability in terms of estimation and track record for policy use. However, they typically do not explicitly model the interaction of the financial

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[5] In principle, in the short-run the reduction in aggregate demand should lower inflationary pressures and induce a monetary policy easing which could partially offset the increase in lending spreads. As discussed in Section 3.4, we overlook this effect since we focus on the long-term impact of the new regulation on output, which is assumed to be independent of monetary policy. In other words, we adopt the standard assumption of long-run neutrality of monetary policy.

sector and the economy: banks' balance sheet conditions and income statements are typically missing or, if present, do not play an important role (they are affected by the dynamics of the economy, but do not feed back into it). Moreover, the computation of steady state effects is often difficult due to the size of the models, and long-term effects can be approximated only by simulations over a reasonable number of years. Finally, in many cases models in this class are subject to the Lucas critique: since agents' expectations are not fully modeled, the effects of a change in economic policy are predicted entirely on the basis of relationships observed in historical data. For this reason, only two models of this class were used in this paper. The model used by Locarno is a "maquette" (much smaller than the "parent" large-scale semi-structural model), where agents learn adaptively and adjust expectations on the basis of economic outcomes, policy changes included. The Bank of England model maintains a fairly rich structure, but it has a DSGE core where expectations are modelled. The economic mechanisms at work in the semi-structural models are similar to the ones outlined above.[6]

Finally, we present results obtained with a vector error-correction model (VECM) that estimates long-run relationships among a small set of macro variables for the US, including bank ROE, interest rates, lending, bank liquidity and capitalization.[7] The main advantage of this approach is that it helps to disentangle loan demand and loan supply factors in the steady state; the main disadvantages are that it does not allow us to conduct counterfactual experiments and that the estimates are subject to the Lucas critique.

3. Methodology

Three crucial elements of the new regulatory framework are higher minimum capital ratios, higher quality of capital, and tighter liquidity requirements. To answer the questions listed in the introduction we need to "feed" these features into the available macroeconomic models. This is all but straightforward. First, some of the models do not feature bank liquidity, or bank

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6 Both these models can provide the steady state impact of regulatory changes on output. In general, this exercise cannot be performed with the semi-structural models used in the MAG report, as steady states for different parameter configurations cannot be easily computed. We make reference to the end-period of the simulations run by MAG (2010b) (the last quarter of 2020) as an alternative measure of the effect of the new regulation on long-term output.

7 This VECM model draws on the VAR used in MAG (2010a) for the US, but focuses on the long term relationships among the macro-variables in levels.

capital, or both. Second, even the models featuring bank capital are typically estimated or calibrated based on measures of capitalization other than the TIER 1 measure chosen in the Basel III accord. Third, even the models that feature bank liquidity adopt very simple definitions (eg the ratio of cash and government bonds to total assets), quite distant from the complex measures introduced by the new rules.

Addressing these difficulties represented one of the key challenges for the exercises conducted in the paper, and an important element to assess the reliability of the results. This section describes the strategy adopted to this end.

3.1 Impact on long-term (steady state) value of output

For the models that explicitly feature a minimum capital-to-assets ratio ν, it was possible to implement higher steady state values, $\bar{\nu}$, and look at the new steady state levels of the key macro variables (output, consumption), in deviation from the baseline value. This represents our summary measure of the long-term cost of tighter capital requirements on the key macroeconomic variables. For the models that also feature bank liquidity, the new liquidity regulation is "translated" into model inputs in terms of an increase in the liquid/total assets ratio. As we explain in Section 4, our simulations should approximate the introduction of the Net Stable Funding Ratio (NSFR), which addresses the maturity mismatches between banks' assets and liabilities. The exercise is otherwise analogous to that for capital described above.

For the models featuring bank capital but not bank liquidity the tightening of liquidity standards can be proxied in various ways. Since all these models feature an interest rate spread, defined as a lending rate minus a rate on deposits (or a policy rate), we assume that the new liquidity regulation causes a widening of the spread. The idea is that tighter liquidity standards will reduce banks' profitability, which banks will (partly) offset by increasing the interest rate on loans and/or decreasing the remuneration on deposits (assuming the degree of competition is unaffected by the new regulation). The same approach is followed by MAG (2010a) and BCBS (2010b). To implement this approach, prior knowledge about the relationship between liquidity and spreads is required. This issue is addressed in Section 4, where we rely on estimates conducted by MAG (2010a), BCBS (2010b), and King (2010). The estimated values of the spread are then fed into the models.

For the models featuring neither bank capital nor liquidity, we follow the same approach: tighter capital and liquidity requirements are mapped into values of the interest rate spread.

Section 4 presents this mapping, based on the references mentioned above. Interestingly, some of the models with bank capital can be used to validate this approach. In these models the increase in the capital target can be implemented directly and creates an endogenous response of the interest rate spread. This response was roughly in line with the estimates in King (2010) and provided a consistency check across the results obtained with the two sets of models.

Summing up, for the models that do not feature capital, liquidity, or both, we adopt a two-step approach: we first consider the impact of the new rules on interest rate spreads; next, these spreads are fed into the available models. Admittedly, tighter capital or liquidity requirements could have effects on other aspects of banks' behaviour; furthermore, the change in spreads may depend on structural features of the financial system which may differ across countries. Therefore, in the following sections we cross-check the results obtained from the various model types.

3.2 Impact on output variability

The impact of the new regulation on the variability of the economy was assessed using DSGE models (the exercises described below cannot be implemented with the other models used in the paper). This yields a measure of the benefits of Basel III, although a partial one, as it is limited to the potential reduction of the volatility of the key macro variables. Running the exercises involves a decision concerning which shocks should be used (technology shock, aggregate demand shock, …). Since some models are calibrated, and cannot be used to make a firm statement regarding the relative importance of the various shocks for the business cycle, we look at the effect of the new regulation under a technology shock, typically important in this class of models. However, given that the tighter prudential requirements would not be shock-contingent, to check the robustness of the results we also conduct simulations with all the model shocks.

(i) Unconditional volatility – First, we look at the unconditional standard deviations of the key macroeconomic variables under the new steady state, and compare them with their respective baseline values (those measured in the pre-reform steady state).[8] Volatility effects are unlikely

[8] Unconditional variances can easily be computed from the solution of the linearized model. Using the state-space representation we have: $x_t = Ax_{t-1} + B\varepsilon_t$, $y_t = Cx_t$, where x_t are the state variables of the model,

to be fully captured, due to the fact that first order (linear) approximations of the models are used for the exercises. However, using higher order approximations for the models presents several methodological challenges, and was deemed unfeasible for our purposes.

(ii) Countercyclical capital requirements rule – Countercyclical capital buffers, widely discussed in several fora, including the Basel Committee (see BCBS 2010a), were recently introduced in the regulation by the Basel III reform package. To gauge the effect of introducing such a buffer for the variability of the economy, we use the sub-group of models featuring bank capital, and link the capital requirement to the dynamics of a key macroeconomic variable. We experimented with the following rule:

$$\nu_t = (1-\rho_\nu)\bar{\nu} + (1-\rho_\nu)\chi_\nu X_t + \rho_\nu \nu_{t-1} \tag{1}$$

where ν_t is now a time-varying target capital ratio, $\bar{\nu}$ is as before the steady state level of ν_t. In section 5.2 we define X_t as the detrended loans/output ratio in line with BCBS (2010a). However, other possibilities have been explored in the literature. The reaction of ν_t to changes in X_t is measured by the sensitivity parameter χ_ν>0. Ad hoc values for the parameters were chosen. In particular, we set ρ_ν=0.9; model-specific values of χ_ν were chosen so as to produce reasonable changes in ν_t around $\bar{\nu}$: a range of plus or minus 2 percentage points around $\bar{\nu}$ was considered "reasonable". This is broadly in line with the range of 0 to 2.5 per cent recently announced by the regulators for the countercyclical capital buffer (Wellink, 2010; BCBS, 2010a).

Once equation (1) is added to the model, the analysis described above can be replicated: unconditional variances can be computed and compared to their values in the baseline version of the model.

3.3 Impact on welfare

The exercises illustrated in Section 3.1 yield estimates of the costs of tighter prudential requirements in terms of lower steady state levels of the key macro variables. A second measure of these costs is overall welfare, a meaningful concept within the DSGE framework.

ε_t are the structural shocks and y_t is a vector containing variables of interest. One can then compute: $Var(x_t) = AVar(x_t)A' + BVar(\varepsilon_t)B'$ and $Var(y_t) = CVar(x_t)C'$.

Relative to the simple assessment based on output, welfare takes into account additional potentially important aspects of the results. For instance, a small loss in steady state output could reflect a large increase in hours worked, offset by a fall in consumption. In this case, the cost of the new regulation measured in terms of welfare would be much larger than the simple measure based on the output loss.

We compute the welfare-equivalent permanent loss in consumption, in percentage deviation from the baseline steady state, caused by the regulatory tightening. This is the fraction of consumption that consumers would be willing to permanently give up to avoid the tightening. There are various ways to do a welfare calculation.

(i) Using the Van den Heuvel formula – The following simple formula, derived by Van den Heuvel (2008), expresses the welfare cost of raising the capital requirement by $\Delta \bar{v}$, as a fraction of consumption:

$$Cost = \frac{D}{C}(R^E - R^d - g_D)\frac{\Delta \bar{v}}{(1-\bar{v})} \tag{2}$$

Here, D is total deposits (aggregate for the economy's banking system), C is aggregate consumption, R^E is the risk-adjusted return on equity, R^d is the (average) interest rate on total deposits and g_D is the share in the non-interest cost, net of any fees, that is attributable to attracting and servicing deposits. This last item can be bound as follows: $0 \le g_D \le g/D$, where g is operating expenses minus non-interest income (aggregates for the banking system). This leads to an upper bound on *Cost* (when $g_D = 0$) and a lower bound (when $g_D = g/D$). The key factor in the formula is the spread between the risk-adjusted return to equity and deposits. Intuitively, this reveals the value of liquidity creation by banks, which in turn allows banks to lend at lower rates to firms, to the extent that the spread exceeds the cost of intermediation. Increasing the capital requirement reduces this boost to capital accumulation. The bank debt-to-consumption ratio concerns the importance of bank intermediated finance in the economy.

An alternative version of formula (2) is the following:[9]

$$Cost = \frac{D}{C}\left[\frac{(R^L - R^d - g/L)}{\bar{v}} - g_D\right]\frac{\Delta \bar{v}}{(1-\bar{v})} \tag{2'}$$

where R^L is the (average) return on total assets, net of loan losses and other provisions, for the banking system, and L is total assets of the banking system. This alternative formula is used to test for robustness. As in (2), g_D can be set to 0 or to g / D, leading to an upper and lower bound for the estimated welfare effect.

The main advantage of this method is its simplicity. Two disadvantages are that it disregards the effect of the liquidity regulation, and the effect on welfare of the change in the variances likely to be brought about by the new regulation. Since formulas (2)-(2') are to some extent model-specific, we also check the robustness of the results using each particular model's utility functions.

(ii) Using the models' utility functions – The utility function(s) of each model can be simply evaluated at the new steady state levels of the relevant variables. Assume for example that in the model there are two types of consumers i=1, 2, with two different utility functions U_i. Then one can compute the steady state welfare:

$$W(C_1, C_2) = w_1 * U_1(C_1) + w_2 * U_2(C_2) \tag{3}$$

where C_i are vectors of variables including, say, consumption, labour, or deposits, and the weights w_1 and w_2 measure the importance of the two consumer types in the economy.[10] Equation (3) can be used to compute the deviation of steady state welfare from the baseline: $\Delta W_{v,l} = W_{v,l} - W_b$, where W_b ($W_{v,l}$) is welfare in the pre-reform (post-reform) steady-state equilibrium. As above, $\Delta W_{v,l}$ was expressed in terms of welfare-equivalent permanent loss in consumption, in percentage deviation from the baseline steady state.

Relative to measure (i), this method can take into account the effect of liquidity tightening. It shares with method (i) the disadvantage of disregarding variance-related effects, due to the linearity of the model approximations used in the exercises.

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9 This alternative formula exploits an accounting identity relating the return on assets to the return on equity and the cost of other bank liabilities. See Van den Heuvel (2008), p. 312 for details.

10 These weights are usually part of the model. For instance, in Gerali *et al.* (2010) 75 percent of households are savers (patient households), the remaining 25 percent are borrowers (impatient households). In the models featuring only one consumer type, w_2=0.

3.4 Other methodological issues

The above description of the methodology leaves several loose threads. In this section we discuss some of those, which have a bearing on the interpretation of the results.

(i) The role of monetary policy – The unconditional variances and covariances depend on the degree of activism of monetary policy. We chose to keep monetary policy as specified in each model — that is the simulations were run using model-specific Taylor rules. This approach is probably the most realistic way of assessing the incremental stabilization effect of the regulatory reform. The specification of monetary policy has no effect on the steady state levels of the variables, but will impact on the exercises illustrated in sections 3.2 and 3.3(ii).

(ii) The main benefits of reform are overlooked – Tighter standards should translate into fewer and milder crises (BCBS, 2010b). Our models, which abstract from defaults, are unsuitable to tackle this aspect and can only capture benefits coming from the lower volatility of the key macroeconomic variables, to the extent that the new regulation causes such a decline. Even the quantification of these benefits is limited by the linear nature of the models, which cannot capture creation of boom-bust cycles. By contrast, our models can in principle adequately capture the cost of the new regulation in terms of output loss and provide a full answer to question (1). An attempt to measure the full benefits is in the LEI report (BCBS 2010b).

(iii) Reform has no effect on long-term growth rate – Focusing on the decline in the steady state output, relative to a baseline featuring no regulatory reform, implicitly assumes that the reform has no effect on the long-term growth rate of output. This is a standard assumption in macroeconomics: the long-run growth rate is determined by the rate of technological progress, which is exogenous to the model. We did not consider models with endogenous growth. The evidence in BCBS (2010b) indicates that the effect might well be positive.

(iv) Results are independent of the actual degree of bank capitalization – Our results shall give us a measure of the decline in output caused by an increase in the capital ratio, relative to the model steady state. However, the models' steady state may have little to do with the current level of the bank capital ratio in the underlying economies. Our view is that, given the uncertainty surrounding the estimates, cross-country differences stemming from our results should be taken with caution. Indeed, in the conclusions we mainly emphasize an estimate of the long-term reactivity of steady state output to the capital ratio obtained as an average across models and countries.

4. Key inputs to the exercises

Two sets of policy scenarios are considered, for capital and for liquidity, respectively. Following MAG (2010a) and BCBS (2010b), the capital policy scenarios were designed considering tangible common equity (TCE), a concept closely related to the TIER 1 capital measure chosen in the Basel III accord. Specifically, it was assumed that the capital tightening could be proxied by a 2, 4 or 6 percentage-point increase in the ratio between TCE and RWA (Risk-Weighted Assets).[11] Since the actual magnitude of the capital increase to be decided by the Basel Committee was not known when the simulations were performed, the idea was to gauge the reactivity of the economy to capital increases of different magnitudes and to check for the presence of nonlinearities.

The modelling of the liquidity reform presents greater challenges. The approach initially adopted by MAG (2010a) and BCBS (2010b) was to consider a 25 or 50 percent increase in the ratio between banks' liquid and total assets. These two scenarios were meant to provide an assessment of the reactivity of the economy to liquidity requirements, and to yield a lower and an upper bound for the effect of the joint adoption of the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR).[12] The bridge models employed by MAG (2010a) suggest that the 25 per cent increase in the liquidity ratio is associated with an increase in the lending spread by 14 basis points, as shown in Table 1, p. 17 of MAG (2010a), so that, assuming linearity, a 50 per cent increase can be associated with a 28 basis point increase in the spread. The analysis developed later on by King (2010) and incorporated in BCBS (2010b) suggests that these two scenarios approximate the introduction of the NSFR under different assumptions concerning the interactions between the NSFR and capital regulation. In fact, if banks increase liquid assets to reach a higher liquidity ratio, other things being equal, risk-weighted assets decline and the TCE/RWA ratio increases, helping banks meet the tighter capital requirements. The estimates reported in BCBS (2010b) suggest that if these synergies between capital and liquidity regulation are taken into account, meeting the NSFR can be

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[11] We define capital as tangible common equity (TCE) and the capital ratio as the ratio of TCE to risk-weighted assets (RWA). TCE is net of goodwill and intangibles. RWA are measured using historical definitions under Basel I and Basel II. The analysis applies to total TCE held, so that it does not distinguish between the minimum capital requirement and additional capital that banks may hold in excess of the minimum requirement.

[12] See BCBS (2009b) for a description of these ratios. The LCR ensures that banks have adequate funding liquidity to survive one month of stressed funding conditions. The NSFR addresses the mismatches between the maturity of a bank's assets and liabilities.

modelled by a 14 basis point increase in lending spreads; if instead the synergies are not taken into account, meeting the NSFR can be modelled by a 25 basis point increase in lending spreads.[13]

Piecing these estimates together, we assume that meeting the NSFR can be modelled by a 50 per cent increase in the ratio between liquid and total assets (to be used as an input in models featuring bank liquidity), or by a 25 basis point increase in the lending spread (to be used in models without bank liquidity), if the above mentioned synergies between capital and liquidity regulation are not taken into account. By contrast, if these synergies are considered, meeting the NSFR can be modelled by a 25 per cent increase in the ratio between liquid and total assets, or a 14 basis point increase in the lending spread.

This interpretation, which we follow in the rest of the paper, is summarized in Tables 2 and 3. The same interpretation is also adopted in BCBS (2010b), that sees the NSFR as the more relevant constraint for economic growth in the long run, and does not perform an assessment of the LCR also due to data limitations.

(i) Models featuring bank capital and liquidity – For these models the exercise is relatively straightforward. A problem is that the definitions of capital and assets used in the various models are heterogeneous, and are different from TCE/RWA.[14] To address this problem, in most of the models we assume that a one percentage point increase in TCE/RWA translates one-to-one into the capital ratio adopted in the models. Gambacorta and King (2010) show that this approximation is acceptable on average over several alternative definitions of capital. In some cases, when the differences were not negligible, capital ratios were mapped into the TCE/RWA definition using the conversion tables provided in Annex 5 of BCBS (2010b).

As previously mentioned, two liquidity scenarios were run: the model-specific ratio between liquid and total assets was increased by 25 or 50 per cent; the 50 per cent scenario can be interpreted as imposing the NSFR without taking the synergies between capital and liquidity into account, whereas the 25 per cent scenario proxies for the adoption of the NSFR accounting for these synergies.

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[13] The final estimates provided in King (2010) are slightly lower, at 12 and 24 basis points, respectively.

[14] For instance, Gerali *et al.* (2010) was estimated using total capital and non-risk-weighted assets.

Table 2

Impact of regulatory tightening on bank capital and interest spreads

Inputs for models featuring bank capital[1]

Policy scenarios (direct inputs for models with bank capital and liquidity)		**Model inputs** (for models without bank liquidity)	
Increase in capital ratio (Tangible common equity/risk-weighted assets) relative to current level (a)	Target liquidity tightening, relative to current level (b)	Increase in model-specific capital ratio induced by (a), relative to model's baseline steady state value (c)	Increase in bank spread induced by (b), relative to model's baseline steady state value (d)
(percentage points)	(percentage increase)	(percentage points)	(basis points)
2	25	2	14
4	25	4	14
6	25	6	14
2	50	2	25
4	50	4	25
6	50	6	25

[1] Columns (a) and (b) list the combinations of capital and liquidity targets defining the policy scenarios. Capital requirements are defined in terms of the ratio between tangible common equity and risk-weighted assets (TCE/RWA), while liquidity requirements are defined in terms of the ratio between liquid and total assets. The next two columns "translate" the policy scenarios into inputs to be fed into the available models. Specifically, Column (c) "translates" the increase in TCE/RWA into increments of the ratio total capital/total assets, to be applied to the baseline value of the ratio. Column (b) is already an input for models featuring bank liquidity. Column (d) "translates" the tightening of liquidity requirements into increments of the interest rate spread, to be applied to the baseline value of the spread for the models featuring bank capital but not bank liquidity. In either case, "baseline" is to be intended as the steady state value implemented (estimated or calibrated) in each model. The spread is defined as the difference between the loan and deposit rate (or a monetary policy rate, depending on the model). See Table 1.

Table 2 summarizes these assumptions. Specifically, columns (a) and (b) report the policy scenarios for capital and liquidity. For this class of models, these two columns are also the model inputs.

(ii) Models featuring bank capital but not bank liquidity – For these models the capital scenario is handled as before: column (c) is a duplicate of column (a). By contrast, the liquidity tightening must be "translated" into model inputs. To this end, as discussed above, we assume that the tightening increases the steady state level of the interest rate spread. We use the estimates in BCBS (2010b) reported above in column (d) of Table 2.

Table 3

Impact of regulatory tightening on bank capital and interest spreads: DSGE models without bank capital[1]

Policy scenarios				**Model input**
Increase in capital ratio (Tangible common equity/risk-weighted assets) relative to current level (a)	Target liquidity tightening, relative to current level (b)	Increase in bank spread, relative to model's baseline steady state value, induced by (a) (c)	Increase in bank spread induced by (b), relative to model's baseline steady state value (d)	Total impact of regulatory tightening on bank spread (e) = (c) + (d)
(percentage points)	(percentage increase)	(basis points)	(basis points)	(basis points)
2	25	26	14	40
4	25	52	14	66
6	25	78	14	92
2	50	26	25	51
4	50	52	25	77
6	50	78	25	103

[1] Columns (a) and (b) represents the policy scenarios, where tighter capital requirements are defined in terms of percentage points increase in the ratio between tangible common equity/risk-weighted assets (TCE/RWA), while tighter liquidity requirements are defined in terms of percentage increase in the ratio between liquid and total assets. The next two columns "translate" the policy scenarios into the interest rate spread to be fed into the available models. Specifically, Column (c) "translates" the increase in TCE/RWA into increments of the spread; Column (d) does the same for the tightening of liquidity requirements. Column (e) reports the total increment of the spread, to be applied to the baseline value of the spread. "baseline" is to be understood as the steady state value of the spread implemented (estimated or calibrated) in each model. The spread is defined in most of the cases as a rate on loans minus a rate on deposits, or a monetary policy rate, depending on the model. See Table 1.

(iii) Models featuring neither bank capital nor bank liquidity – Table 3, to be used for the models without bank capital or liquidity, "translates" both the capital and the liquidity tightening into a spread equivalent, using the same logic. Column (d) is equal to its counterpart in Table 2. Column (c) relies once more on BCBS (2010b): a one per cent increase in Tier 1 capital yields a 13 basis point long-term increase in lending spreads (cross-country median in the sample).[15] This estimate is in line with recent studies measuring the long-run effects of higher capital requirements on banks' lending spreads. Elliot (2009, 2010) and Hanson, Kashyap and Stein (2010) for the US, Schanz (2010) and Osborne *et al.* (2010) for the UK argue that these effects are modest, especially if banks are able to offset the increase in funding costs, eg through a reduction in banks' required return on equity and a

[15] The estimates provided in King (2010) are slightly higher, at 15 basis points.

decrease in borrowing costs, as banks become safer.[16] Altogether, these estimates of the impact of a one percentage point increase in the risk-weighted capital ratio are in a range of 3 to 10 basis points. Overall, these considerations suggest that the figures in Columns (c) and (d) might be in the upper part of a range of reasonable estimates.[17]

5. Results

5.1 Impact on long-term (steady state) output

First, we look at the impact of the new regulation on steady state output. This is measured by the percentage deviation of the new steady state levels from the baseline. Results are in Table 4.

The first two columns report the regulatory scenarios, discussed in the previous section. The next five columns report results from the various models, aggregated according to geographical area or model type (medians of individual model results are reported). The remaining columns report various statistics, such as averages and dispersions. These results prompt the following observations.

First, the output response appears to be approximately linear.[18] This feature implies that our results can be interpreted as a measure of the long-run reactivity of output to the capital requirement, ie of the decline in steady state output that is to be expected if the capital requirement is increased by one percentage point, say. Doubling the increase doubles the effect on output. The same reasoning applies to the reactivity of output to the interest spread.

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[16] The Modigliani-Miller theorem is a sufficient but not a necessary condition for this result to hold. See Hanson, Kashyap and Stein (2010) and Admati et al. (2010) for an articulation and discussion of this argument.

[17] This conclusion is strengthened by the fact that King's estimates are based on three conservative assumptions: (i) any increase in funding costs or reductions in interest income caused by the new regulation are fully passed on to customers via an increase in the interest rate spread; (ii) the cost of debt does not fall as banks become less risky; (iii) banks maintain their ROE at the 1993–2007 average. This is nearly 15 per cent, historically high. If the steady-state ROE is assumed to be 10 per cent, each one percentage point increase in the capital ratio raises the loan spread by only 7 basis point.

[18] Most of the models used in the paper are linear approximations around a steady state. However, this is not the source of the linearity of the results, since the results themselves are derived by comparing different steady states.

Table 4

Steady state output loss due to regulatory tightening[1]

Increase in TCE/RWA ratio relative to current level	Target liquidity tightening, relative to current level	Euro area, DSGE models		US		Italy, UK	Avg.	Std Dev	Min	Max	Median	No. of models
		with bank capital	without bank capital	DSGE and VECM models, with bank capital	DSGE models, without bank capital	Semi structural models, without bank capital						
(percentage points)	(percentage increase)	(percentage deviation from baseline)										
2	0	0.29	0.24	0.10	0.29	0.29	0.25	0.20	0.04	0.70	0.20	13
4	0	0.53	0.49	0.25	0.57	0.58	0.47	0.35	0.07	1.10	0.33	13
6	0	0.81	0.72	0.35	0.83	0.84	0.68	0.50	0.07	1.58	0.50	13
2	25	0.34	0.34	0.20	0.40	0.45	0.37	0.30	0.00	1.07	0.25	13
4	25	0.63	0.61	0.35	0.72	0.73	0.61	0.44	0.08	1.47	0.42	13
6	25	0.86	0.86	0.50	0.96	0.99	0.80	0.56	0.08	1.85	0.59	13
2	50	0.49	0.48	0.29	0.56	0.56	0.51	0.40	0.07	1.52	0.33	13
4	50	0.73	0.72	0.49	0.82	0.83	0.72	0.52	0.07	1.83	0.50	13
6	50	0.96	0.96	0.59	1.06	1.09	0.92	0.63	0.07	2.05	0.65	13

[1] Columns 3 to 7 of the table report median values, computed using the subset of models described in each column heading. The statistics on the right-hand side of the table (Average, …) are computed using estimates from all 13 models.

Source: authors' calculations

Second, the grouping by region presented in the table does not highlight dramatic cross-country differences. Where present, the differences seem to be mainly driven by modelling choices. The individual effects range from very small to sizeable (see the columns "min" and "max"). This underscores the degree of uncertainty surrounding these estimates, and led us to focus on the mean or median of the estimates computed using all the available estimates (columns to the right), to be interpreted as broadly representative of the average or median effects for an industrialized economy. The standard deviations reported in the column next to the mean effects are not a rigorous measure of uncertainty for the exercises being conducted, but can be used heuristically. Looking at a range of ± two standard deviations around the point estimates suggests that in several scenarios the effect is not statistically different from zero. Rigorously computed confidence bands, available for some models, confirm this result.

Third, considering all models, the point estimates suggest that a one percentage point increase in the capital requirement roughly translates into a 0.09 per cent median loss in steady state output.[19] Average values are slightly higher, indicating that the distribution of the estimates is skewed to the left. Note that, for the US, the difference between the results obtained from models with and without bank capital is relatively large; for the euro area the difference is much smaller and has the opposite sign. Overall, this suggests that models with and without bank capital deliver broadly comparable results.

MAG (2010b) calculates simulated paths for GDP extending to 2022 using a variety of models and assumptions. Although most of these models are primarily designed to estimate short and medium term policy effects, the end-of-period loss relative to the baseline can be taken as an alternative measure of the long-term impact of the new regulation, given the long horizon of the simulation. The loss for a one percentage point increase in the capital ratio is 0.10 per cent (median across all models).

Fourth, the higher liquidity requirements lead to an additional decline in the level of output (see lines 4–9). This additional effect can be gauged as the difference between the "capital only" scenarios (first 3 lines of the table) and the "capital and liquidity" scenarios (lines 4–9). Considering medians, a 25 percent increase in the liquid/total assets ratio causes a 0.08 per cent fall in output relative to baseline (this estimate is in line with the values provided by MAG (2010a) for the end of the simulation period). A 50 per cent increase causes output to fall by 0.15 per cent, hence the effect is approximately linear, as in the case of capital.[20] Recall that the 25 per cent liquidity scenario can be interpreted as measuring the effect of meeting the NSFR if the synergies between the capital and liquidity regulation are taken into account, whereas the 50 per cent scenario amounts to ruling out these synergies.

5.2 Impact on output variability

In this section we examine the potential effects of the new regulation on the variability of output. We reiterate the above caveat, that the use of first-order (linear) approximations of the

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[19] This is calculated as the average impact across the figures reported in Table 4, lines 1–3, column "Median"; ie (1/3)*(.20/2 + .33/4 +.50/6)= 0.09.

[20] These effects are calculated by averaging the medians in lines 4–6 and 7–9, column "Median" of Table 4, after subtracting the corresponding figure in lines 1–3. Eg for meeting the NSFR with a fall in RWA, the effect is computed as (1/3)*(0.25–0.20 +0.42–0.33 +0.59–0.50)=0.08.

models might have more important effects on the results of this section. A more thorough analysis of the variance-related effects should be performed using higher order model approximations. Furthermore, most of the models do not take into account positive effects of tighter regulatory requirements as the riskiness of debt contracts and default rates remain unchanged.

We first look at unconditional standard deviations, then move to consider the potential stabilization effect of a counter-cyclical prudential buffer.

(i) Impact of tighter regulation on the unconditional standard deviation of output – The results are in Table 5. As before, the first two columns report the regulatory scenarios, whereas the remaining columns identify the models used in the exercise grouped by region/characteristics of the models. For the reason discussed in section 3.2, the table reports the exercise conducted with the technology shock only. Also note that the number of models used for this part of the analysis drops significantly, from 13 in the previous section to 5–7, which reduces the reliability of the results. With these caveats, the table suggests the following conclusions. First, all the models explicitly featuring bank capital show that higher capital targets induce a decline in output variability. The magnitude of the effect of a one percentage increase in capital differs across models, ranging between a minimum of –0.3 per cent and a maximum of –2.7 per cent relative to the baseline. Within this class of models, a one percentage point increase in the capital-to-asset ratio reduces the standard deviation of output by 1.0 per cent (average of the median values reported in lines 1–3, column "Median" of the table). The impact of tighter liquidity requirements (proxied by a 25 per cent increase in the ratio of liquid asset to total assets to meet the NFSR, see the previous section) reduces the standard deviation of output by a further 1.0 per cent.[21] Second, not surprisingly, the models that do not feature bank capital, and have to approximate the regulatory tightening only via an increase in the lending spread, yield a somewhat different message: the standard deviation of output declines by a much smaller amount, and in one case it actually increases (column US – DSGE models without bank capital). This difference is more evident when considering all shocks (not reported).

[21] As in Section 5.1, this effect is calculated by averaging the medians in lines 4–6 of Table 5, column "Only models featuring bank capital", after subtracting the corresponding figure in lines 1–3: (1/3)*(–3.1+1.9 – 4.6+3.9–7.1+6.0)=1.0.

Table 5

Change in the standard deviation of output due to regulatory tightening: DSGE models[1]

Increase in TCE/RWA ratio relative to current level	Target liquidity tightening, relative to current level	Euro area		US		Only models featuring bank capital[2]	Avg.	Std Dev	Min	Max	Median	No. of models
		with bank capital	without bank capital	with bank capital	without bank capital							
(percentage points)	(percentage increase)	(percentage deviation from baseline)										
2	0	–2.8	–	–0.5	–	–1.9	–2.5	1.9	–5.1	–0.5	–1.9	5
4	0	–5.4	–	–1.1	–	–3.9	–5.2	3.7	–10.8	–1.1	–3.9	5
6	0	–7.7	–	–1.5	–	–6.0	–7.6	5.6	–16.4	–1.5	–6.0	5
2	25	–3.4	–0.6	–1.4	–0.1	–3.1	–1.8	1.8	–4.6	0.0	–1.4	7
4	25	–4.7	–0.9	–2.2	0.0	–4.6	–3.2	3.7	–10.4	0.4	–2.2	7
6	25	–7.4	–1.3	–3.1	0.3	–7.1	–4.8	5.8	–16.0	1.2	–3.1	7
2	50	–4.0	–0.7	–3.7	0.0	–3.8	–2.5	2.3	–5.9	0.3	–3.4	7
4	50	–8.4	–1.1	–5.4	–0.1	–6.9	–4.3	4.0	–9.9	0.4	–5.4	7
6	50	–10.2	–1.5	–7.0	0.2	–8.9	–5.9	5.9	–15.5	1.1	–7.0	7

[1] Change in unconditional standard deviations when the economy is hit by a technology shock. A dash means that the simulation has not been computed within the model. Columns 3 to 7 report median values, computed using the subset of models described in each column heading. The statistics in column 8–10 (Average, …) are computed using estimates from all the available models. [2] With the exception of the Gerali model, these models also feature bank liquidity.

Source: authors' calculations

The decline in output variability arises from lower leverage of banks induced by tighter regulatory measures. Higher capital and liquidity requirements raise the cost of external finance and reduce the loans-to-output ratio. The lower leverage mitigates the variability of consumption of agents financing their spending at least partially via loans. This attenuation mechanism is more clearly present in the case of models that include bank capital and particularly effective with respect to productivity shocks, that typically induce large shifts in asset prices and hence in debt financing. Heterogeneous implications for the variability of output across models might reflect different magnitudes of declines in leverage stemming from differences in the share of consumption financed by loans. Given the very limited range of effects that are allowed to operate in the case of models that do not feature bank capital and liquidity, the findings indicate that the estimates derived from models explicitly featuring bank capital and liquidity are more reliable for the purposes of the present study.

Summing up, the analysis indicates that, in the subset of models that could be used and are more relevant, the reforms would tend to dampen volatility somewhat.

(ii) Countercyclical buffers – Table 6 reports the results obtained by augmenting (some of) the models with the capital requirement rule (1) presented in Section 3. The purpose of these exercises is to obtain an assessment of the potential effect of a time-varying, countercyclical capital buffer, as proposed by BCBS (2010a) and recently introduced by the Basel III reform package. Adding rule (1) to the model causes the capital requirement to increase proportionally to the loan-to-output ratio. Following the specifications of the exercise, the rules have been calibrated so as to produce "reasonable" movements in the capital requirement (± 2 percentage points around the steady state), so as to simulate a capital buffer of about 4 percentage points.

Based on the available estimates, the reduction in the standard deviation of output relative to the baseline in the case of a technology shock ranges from 10 to 22 per cent. Note that this effect is to be added to the improvement brought about by higher capital requirements, illustrated in Table 5.

While the effect is evident, these results should obviously be taken with some caution. They are available only for a small number of models, as shown by the table. And the strength of the effect may depend on the aggressiveness and forward-lookingness of the prudential rule (1). In particular, the large decline in output variance brought about by the rule in some cases may be partly due to the fact that monetary policy is not allowed to react to the introduction of the countercyclical buffer. Angelini, Neri and Panetta (2010) study this interaction within a setup similar to the model of Gerali et al. (2010) and show that when the coefficients of a simple Taylor rule are chosen optimally (ie so as to minimize a weighted average of the variance of inflation and output), the improvement in output variance brought about by the capital rule can be significantly smaller.

Telling whether a prudential rule such as (1) can contribute to dampen output fluctuations requires taking a stand on the relative importance of shocks for macroeconomic fluctuations. For certain shocks as technology shocks, an expansion of output tends to be accompanied by a faster rise in credit demand. The countercyclical capital rule will help dampen both—the credit and output growth.

Table 6

Change in output standard deviation due to countercyclical capital buffers: DSGE models[1]

Increase in TCE/RWA ratio relative to baseline	Target liquidity tightening, relative to baseline	Average	Std Dev	Min	Max	Median	Number of models
(percentage points)	(percentage increase)	(percentage deviation from baseline)					
2	0	–16.7	6.1	–22.4	–10.2	–17.6	3
4	0	–18.4	2.8	–21.6	–16.3	–17.2	3
6	0	–19.8	2.8	–21.6	–16.6	–21.3	3
2	25	–16.7	6.4	–22.5	–9.8	–17.9	3
4	25	–18.0	2.4	–20.7	–16.0	–17.2	3
6	25	–19.8	2.9	–21.5	–16.4	–21.4	3
2	50	–16.7	7.0	–23.3	–9.3	–17.6	3
4	50	–17.9	3.0	–21.3	–15.6	–16.8	3
6	50	–20.1	3.7	–23.3	–16.0	–21.1	3

[1] Change in unconditional standard deviations when the economy is hit by a technology shock. In the baseline no countercyclical rules are in place.

Source: authors' calculations

However, other shocks as a housing preference shock (ie an increase of utility from housing) may induce households to cut consumption (causing a fall in output), and to raise the demand for loans to finance house purchases (causing an increase in credit). In this case the countercyclical capital buffer dampens the credit growth, but may in principle exacerbate the downswing causing larger output variance.[22] However, the conditioning variable cannot be "shock dependent" and has to provide a good result in general.[23] It is also worth noting that the countercyclical capital rule that has been implemented by BCBS (2010a), differently from

[22] In a recent contribution resorting on a DSGE model incorporating financial frictions, heterogeneous agents and housing, Beau et al. (2011) show that leaning against credit growth policy reduces output volatility in the case of financial, credit or housing preference shocks by dampening the propagation of these shocks to the real economy. Their result holds for the versions of their model estimated both for the euro area and the US.

[23] A more in-depth analysis of these issues and a discussion of alternative forms of countercyclical capital buffer is provided in Drehmann et al. (2010).

equation (1), comes into operation only after certain thresholds have been exceeded – intended to capture unsustainable credit booms – and the buffer is released as signs of stress emerge. This reinforces its stabilizing properties compared with what can be reproduced in the model, which assume that the minimum is binding at all times, and which cannot model unsustainable booms followed by stress.[24]

5.3 Impact on welfare

Finally, we examine the impact of the new regulation in terms of welfare. Formulas (2) and (2') presented in Section 3.3.(i), based on the formula developed in Van den Heuvel (2008), are implemented primarily using data from the OECD's Bank Profitability Statistics. Attention is restricted to those countries in our group for which the data are available in that source: Canada, France, Germany, Italy, the Netherlands, Spain and the United States. The sample is set at 1986–2007 to get reasonable long-run measures of the spreads involved. The variables in (2) and (2') are measured as follows:

D	either 'Customer deposits' (we call this 'Narrow deposits'), or 'Liabilities' *net* of 'Capital and Reserves' (we call this 'Broad deposits');
C	final consumption expenditures of households (OECD, national accounts);
R^E	proxied by the long-term government bond yield plus 45 basis points (OECD, financial indicators);[25]
R^D	'Interest income' divided by 'Broad deposits'; and
g	'Operating expenses' minus 'Net non-interest income'
R^L	('Interest income' minus 'Net provisions') divided by 'Assets', then risk adjusted[26]
L	'Assets'

The notion of bank capital in the model is total capital, so throughout $\bar{\nu}$ is set at 0.08 (the minimum ratio for total capital as a fraction of risk-weighted assets). As before, we consider increases of the target capital ratios for tangible common equity as a fraction of risk-weighted

[24] See Bianchi and Mendoza (2010) and Jeanne and Korinek (2010).

[25] The 45 basis points is an estimate of the liquidity premium in government bonds. This is based on the average difference between the yields on subordinated bank debt and long-term Treasuries in the US. Subordinated debt counts towards regulatory bank capital albeit within some limits.

[26] The risk-adjustment of R^L follows Van den Heuvel (2008). We compute, for each country, the historical standard deviation of the spread between assets and deposits, net of noninterest cost, ie of $R_t^L - R_t^D - g_t / L_t$. Treating R_t^D as a risk-free rate and conservatively assuming that all the spread is market-priced risk and that the annual market price of risk is 0.5, we deduct 0.5 times the historical standard deviation from the spread.

assets. The results are reported in Table 7. Because the formula is a linear approximation, the table reports the estimated welfare cost per 2 percentage points increase in the capital requirement.[27] For increases of 4 or 6 per cent, the numbers in the table should be multiplied by 2 or 3, respectively.

The first two lines use equation (2) under the assumption $g_D = 0$ (deposit taking involves negligible non-interest costs) or $g_D = g/D$ (all noninterest costs are attributable to deposits). The remaining four lines use the return on total assets, according to equation (2'), alternatively using narrow and broad deposits for D as well as the two bounds for the noninterest cost of deposit taking.

Overall, the median computed across all the available estimates (bottom right-hand corner of the table) suggests that increasing the capital requirement by one percentage point causes a long-run consumption equivalent loss of 0.09 per cent – the same point value obtained from the analysis in Section 5.1. As above, there is a degree of heterogeneity across countries, which is reflected in a relatively large value of the standard deviations computed using the point estimates.

Finally, the welfare-based measure was also computed also using some of the available models. In principle, this measure has more desirable properties than the previous one, as it jointly accounts for the effect of the capital and the liquidity tightening. Results for the increase in the TCE/RWA are very similar. The point estimates suggest that a 1 percentage increase in the capital requirement translates into a 0.06 per cent loss in steady state output using the median value across the available models (0.13 per cent using the mean). These values are in line with those discussed in Section 5.1. Including the synergies between meeting the higher capital requirements and the NFSR – the case that includes the impact on RWA – the estimated decline in steady state output induced by the new liquidity requirements is 0.03 per cent (median) or 0.07 per cent (mean).

[27] Based on a full numerical solution of the model calibrated to US data, Van den Heuvel (2008) documents that the error in the linear approximation is very small for the magnitude of the increases considered here.

Table 7

Steady state welfare loss per 2 percentage point capital tightening in terms of consumption equivalents: formula-based measures[1]

(expressed as a percentage of steady state consumption)

	Canada	**France[2]**		**Germany**	**Italy**	**Nether-lands[3]**	**Spain**	**United States**	**Japan[4]**	**Avg[5]**	**St. Dev.[6]**
Equation (2), g_D=0	0.16	0.13	0.10	0.15	0.17	0.26	0.23	0.07	0.10	0.16	0.06
Equation (2), g_D=g/D	0.11	0.09	–	0.07	0.10	0.14	0.15	0.03	–	0.10	0.04
Eq. (2’) using Narrow deposits, g_D=0	0.27	0.02	–	0.08	0.09	0.34	0.18	0.16	–	0.16	0.11
Eq. (2’) using Narrow deposits, g_D=g/D	0.22	0.00	–	0.01	0.03	0.23	0.11	0.12	–	0.10	0.10
Eq. (2’) using Broad deposits, g_D=0	0.39	0.08	–	0.16	0.27	0.72	0.30	0.24	–	0.31	0.21
Eq. (2’) using Broad deposits, g_D=g/D	0.34	0.04	–	0.09	0.20	0.60	0.22	0.20	–	0.24	0.19
Median	0.25	0.06	–	0.09	0.13	0.29	0.20	0.14	–	0.18	0.14
Mean	0.25	0.05	0.10	0.09	0.14	0.38	0.20	0.14	0.10	0.16	

[1] Welfare loss due to tightening per 2 percentage point increase in the capital requirement, computed using expressions (2) and (2’) (see Section 3.3 for the methodology). As the cost is based on a linear approximation, for higher capital tightening the cost can simply be scaled up proportionately. [2] The figures in the second column have been computed by the Banque de France using a similar formula but a different dataset. [3] The welfare loss may be overestimated since over the sample period a significant fraction of deposits in Dutch banks are held outside the Netherlands. [4] The figures have been computed by the Bank of Japan using a similar formula but a different dataset. [5] The figures in the lines labelled “Median” and “Mean” are computed using all the estimates in the table. [6] The figure at the bottom of the column is the standard deviation computed using all the estimates in the table.

Source: authors’ calculations

6. Summary of results

In what follows we summarize our results by making reference to the three questions formulated in the introduction. The methodological caveats issued there should be kept in mind when interpreting the following.

(1) *What is the impact of higher capital and liquidity requirements on long-term economic performance*? – Two basic measures of this impact have been derived. The first is the loss in steady state output under the new regulatory regime, expressed as a percentage deviation from a baseline (the steady state output value derived under the assumption of unchanged regulation). The second is the welfare loss, measured in terms of consumption. This measure was obtained via a model-based formula, and from a subset of the DSGE models used in the paper.

For the vast majority of models the effects turn out to be linear. This implies that our estimates yield a measure of the decline in steady state output that is to be expected if the capital requirements are increased by one percentage point say. Doubling the increase doubles the effect, regardless of the initial level of the capital ratio. The same reasoning applies to liquidity requirements. It must be emphasized that the linearity property partly reflects methodological choices, and therefore may not be robust. However, given the high degree of uncertainty surrounding the estimates, we believe that these choices are acceptable for the purpose of addressing this question.

Considering the median of the point estimates provided by the models used in the paper, a one percentage point increase in the capital ratio translates into a 0.09 percent output loss relative to the level that would have prevailed in the absence of the capital tightening. This estimate is confirmed by the models that feature bank capital, as well as by those that do not, and by the alternative estimates of the loss, obtained via a model-based welfare formula or via model-consistent measures of welfare. This estimate is also broadly in line with the results obtained in MAG (2010b) for the end of the simulation period (2020), which can be interpreted as an alternative measure of the long-term effect of the new rules.

To gauge the effect of tighter liquidity requirements on output we considered a 25 or 50 per cent increase in the liquid asset/total asset ratio. The steady state output reduction associated with these two scenarios is estimated to be 0.08 and 0.15 per cent, respectively, relative to the baseline (medians across available model estimates). The latter value (0.15 per cent) can be interpreted as the result of imposing the NSFR without taking into account the synergies between capital and liquidity discussed in the paper, whereas the former value (0.08 per cent) proxies for the adoption of the NSFR accounting for these synergies. It is reassuring that these median effects, obtained by pooling the results from all models, reflect fairly similar results from models with and without bank liquidity.

These estimates are surrounded by considerable uncertainty. Given the difficulties of computing a rigorous measure of uncertainty within this context, the paper considers the standard deviations of the point estimates computed using the cross-section of available models. These statistics are of the same order of magnitude as the estimated effects themselves; this suggests that more rigorous tests could fail to reject the hypothesis that the effects are statistically different from zero. The uncertainty associated with the estimates of the economic impact of the new liquidity requirements is higher than for capital, due to a number of factors discussed in the body of the paper.

(2) *What is the impact of higher capital requirements and tighter liquidity regulation on economic fluctuations*? – The models explicitly featuring bank capital show that tighter capital rules induce a decline in output volatility, whose magnitude is heterogeneous across models, ranging from negligible to substantial. Considering technology shocks, a one percentage point increase in the capital-to-asset ratio reduces the standard deviation of output by 1.0 per cent (median across models). The introduction of tighter liquidity requirements (proxied by a 25 per cent increase in the ratio of liquid asset to total assets) reduces the standard deviation of output by a further 1.0 per cent. However, when all shocks are considered, the decline in the standard deviation of output tends to become smaller. Summing up, the reforms may have a modest dampening effect on the volatility of output. However, the results from this part of the analysis are particularly uncertain, given that only a subset of models could be used, and the results are somewhat sensitive to technical assumptions, including model choice.

(3) *What is the impact of the adoption of countercyclical capital buffers on economic fluctuations and on the volatility of bank capital itself?* The simulations have employed a prudential rule which increases the capital requirement when the credit/output ratio increases, so as to generate movements of the capital ratio in a neighbourhood of ± 2 percentage points around its steady state, and to mimic the effect of a capital buffer of about 4 per cent. Obviously, the exercise could be implemented only in the sub-set of models featuring bank capital, which implies a further reduction in the number of simulations available. Overall, such a rule seems capable of reducing in a sizeable way the standard deviation of output (from 10 to 20 per cent of the baseline value). This result is sensitive to a number of factors: the type of shocks hitting the economy; features of the model, including the parameterization of the monetary policy rule; and the details of the prudential rule itself. Further work is required to analyze what specific features would be desirable for such a rule and to assess its economic impact.

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