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## Welfare analysis of bank capital requirements with endogenous default

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## ABSTRACT

This paper presents a tractable framework with endogenous default and evaluates the welfare implication of bank capital requirements. Using a dynamic general equilibrium model we analyze the social welfare response to a negative technology shock under different capital requirement regimes, Basel II and III. In Basel III, we consider alternative indicators, such as output gap and credit-to-output gap. We then consider the scenario where the default rate is augmented in different capital requirement regimes. We show that it is welfare improving by including the default rate as an additional indicator for all capital requirement regimes. A more aggressive reaction to default can effectively mitigate the negative effect of the shock on welfare and this attenuation effect works through the bank funding channel.

## 1. Introduction

This paper develops a dynamic general equilibrium model with endogenous default, and investigates the welfare implication of bank capital requirements when the default rate is considered as an additional indicator. Van den Heuvel (2008) argues that it is critical to understand the welfare implication of bank capital requirements as one would simply raise capital adequacy ratio to 100% if there were no costs of implementing capital requirements. In this paper we argue that changes in the loan default rate can have a significant impact not only on financial intermediaries' bank capital, but also on borrowers' balance sheet and future borrowing capability. It is, therefore, critical for regulatory authorities to consider the effect of default on capital requirements and the implications for social welfare.

Our welfare analysis of capital requirements is related to Van den Heuvel (2008). Using a general equilibrium growth model with liquidity-creating banks, Van den Heuvel (2008) investigates the welfare cost of Basel I and II, and shows that it is equivalent to a 0.1%–1% permanent loss in consumption. Angeloni and Faia (2013) report similar findings on Basel II: risk-weighted capital requirements amplify the cycle and are welfare deteriorating. Basel III, on the other hand, is welfare improving. The above mentioned two articles, however, do not take into the consideration of default when investigating the welfare cost of capital requirements.<sup>1</sup>

The Bank for International Settlements (BIS) has been consistently emphasizing the critical role of default played in the bank capital requirement decision makings (e.g., BCBS, 2009, 2010, 2011). On the academic front, among others, Geanakoplos (2011) and Goodhart et al. (2013) argue that for a long time mainstream macro-models have ignored financial frictions and point out it is important to consider default in macro-models and policy analysis. Catarineu-Rabell et al. (2005) evaluate three possible scenarios where risk weights assigned to bank assets are constant, or depend positively or negatively on the probability of default. The authors find that setting risk weight positively to default is desirable from the regulation point of view. The countercyclical capital buffer of Basel III requires banks to increase their holdings of capital during economic booms. This precautionary regulation aims to curtail credit booms that might end in financial crises. However, not all credit booms lead to crises (see, Bakker et al., 2012). The probability of default can be a good candidate for correcting this potential error: non-beneficial reductions in bank loans. In this paper, we augment the default rate in the capital requirement rule and study the implications for welfare.

Which indicator should be used when implementing the countercyclical capital buffer of Basel III is an empirical question. The BIS suggests that the difference between the aggregate credit-to-output ratio and its long term trend can be a good candidate (BCBS, 2009). There is, however, no general consensus on this. Some studies criticize

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<sup>1</sup> For literature on bank capital requirement in general see, e.g., Repullo (2013); Rubio and Carrasco-Gallego (2014, 2016); Angelini et al. (2015); Kanngiesser et al. (2017).

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this indicator (credit-to-output gap) proposed by the BIS. For instance, Drehmann and Tsatsaronis (2014) argue that the credit-to-output gap is not useful as a warning indicator of banking crises, especially for emerging market economies. Repullo and Saurina (2011) suggest that regulatory authorities should use output growth as the indicator when implementing the countercyclical capital buffer, instead of the credit-to-output gap. Some studies suggest that excessive credit growth is a valid indicator for potential banking crises (e.g., Lowe and Borio, 2002); some suggest the aggregate credit contains information of the likelihood of future financial distresses (e.g., Schularick and Taylor, 2012); and some suggest both deviations of aggregate output and credit from their steady states should be considered (e.g., Resende et al., 2013). In this paper, we consider output gap and credit-to-output gap as potential candidates and compare their performance in terms of welfare.

The contribution of this paper is three-fold. First, to the best of our knowledge, this is the first attempt to study the welfare implication of capital requirements with default, where default is endogenously embedded in the model economy and the default rate is considered as an additional indicator in the capital requirement rule. Second, we investigate whether the proposed countercyclical capital buffer of Basel III does a better job than Basel II in terms of welfare. Third, using social welfare as the criterion, we evaluate different potential indicators, namely credit-to-output gap and output gap, for the implementation of the countercyclical capital buffer.

To study the welfare implication of different capital requirement regimes with endogenous default, we develop a real business cycle model (RBC) with banking, in which borrowers may default on their financial obligations. We introduce endogenous default along the lines of Shubik and Wilson (1977) and de Walque et al. (2010), where borrowers may default on the loans borrowed from the previous period upon paying a penalty cost. We then examine the social welfare response to a negative technology shock under different capital requirement regimes with and without default, that is, a capital requirement regime is responding to the default rate, or otherwise.

By augmenting the default rate in a capital requirement rule we introduce a stabilizer not only in the financial sector but also in the real sector. First, the imposed penalty costs provide firms (the borrower) incentives not to, or default less on bank loans. Second, banks benefit from the augmented capital requirement rule as banks are more profitable and better capitalized with a lower default rate. Banks are, therefore, able to accumulate more funds and supply more credit to firms. This is, in turn, beneficial for production. Last, households can consume and invest (in the form of deposits) more with a higher production. *Ex-ante*, a capital requirement rule responding to the default rate is welfare improving.

The capital requirement regimes studied in this paper are as follows. Following Angeloni and Faia (2013), we assume a fixed rate of bank capital requirement for Basel I. Both Basel II and III evolve as a Taylor-type rule. In the case of Basel II, the capital requirement reacts negatively with respect to output gap. There are two specifications for Basel III. For the first specification, namely Basel III, the capital requirement reacts positively to output gap; and for the second specification, namely Basel III credit-to-output, the capital requirement reacts positively to the credit-to-output gap. We then augment the default rate gap (deviation from its steady state) into Basel II, Basel III, and Basel III credit-to-output.<sup>2</sup>

The results of our welfare analysis are the following. First, introducing default in Basel II, Basel III, and Basel III credit-to-output is welfare improving in all cases. It is through the bank funding channel that introducing default in the capital requirement rule attenuates the negative effect of the shock on welfare. Moreover, a more aggressive reaction

to default can effectively mitigate the negative effect of the shock. Second, compared with Basel II, the countercyclical capital buffer (both Basel III and Basel III credit-to-output regimes) is slightly welfare deteriorating. Last, there is no clear evidence on either credit-to-output gap or output gap is a better candidate for implementing the countercyclical capital buffer. These conclusions are obtained based on the analysis of both the first and second moments of social welfare in response to a negative productivity shock, and complemented by the analysis on the transmission mechanisms through which introducing default in the capital requirement rule attenuates the negative effect of the shock on welfare. The results of sensitivity analysis and significance test suggest our findings are robust.

The rest of the paper is structured as follows. section 2 describes the model. section 3 presents the functional forms and parameters values in the model. section 4 discusses the cyclical properties of our models, and the results of the social welfare analysis and sensitivity analysis. section 5 concludes.

## 2. The model

The model economy is inhabited by households, firms, banks, and a government. Banks intermediate credit between borrowers (firms) and savers (households), facing capital requirement regulation imposed by the government.

We introduce endogenous probability of default into the model as follows. In contrast to de Walque et al. (2010), we assume firms accumulate physical capital with own profits and bank loans. We view this is more in line with the institutional environment, as opposed to the assumption in de Walque et al. (2010) whereby physical capital is accumulated by bank loans only. In each period, firms may default on a fraction of loans borrowed from previous period upon paying a penalty cost. We assume households demand liquidity (deposits) and its usage yield utility in the spirit of Sidrauski (1967). We introduce deposits as households' assets and one kind of banks' liabilities, and model the preferences in a less restrictive way, not depending on modeling choices Van den Heuvel (2008).<sup>3</sup> For simplicity, we assume banks do not default on deposits. Banks supply loans to firms and finance these loans with deposits and own funds (capital).<sup>4</sup> We further assume banks can recover a fraction of defaulted loans upon paying an insurance premium to the government. In our welfare analysis, we consider various types of bank capital requirement regimes that banks face, which are explained in the introduction.

### 2.1. Households

There is a continuum of identical households with mass one. In each period households consume consumption goods,  $C_t$ , and hold bank deposits,  $D_t$ . Households supply labor,  $H_t$ , inelastically to firms and receive a real wage of  $W_t$ .<sup>5</sup> Households are subject to lump-sum taxes,  $T_t$ . Households maximize their expected discounted utility as:

$$\max_{\{C_t, D_t\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, D_t), \quad (1)$$

subject to the budget constraint:

$$C_t + D_t + T_t = R_{t-1}^d D_{t-1} + W_t H_t, \quad (2)$$

where  $\beta \in (0, 1)$  is the discount factor and  $R_t^d$  is the real gross rate of return on deposits.

<sup>3</sup> We acknowledge that choices of utility function affect welfare analysis results. This is, however, beyond the scope of the current study.

<sup>4</sup> Since the study focuses on the welfare analysis of bank capital requirements with default, it is sufficient to have a stylized banking sector in the model.

<sup>5</sup> For simplicity we normalize labor supply to 1.

<sup>2</sup> We only consider the case where the capital requirement reacts positively to the default gap since the otherwise makes no intuitive sense.

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