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Monetary and Macroprudential Policies in an Intangible Economy

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Abstract

Advanced economies are increasingly based on intangible capital. Intangible capital has at least two special characteristics compared to tangible capital. First, it can be simultaneously used to produce different goods. Second, it is less suitable as collateral for obtaining external funds than tangible capital. These features could influence monetary and macroprudential policies. Against this backdrop, we study the effects of monetary and macroprudential policies by using a dynamic stochastic general equilibrium model with intangible capital and a banking sector. In our model, sector-specific productivity shocks to tangible and intangible production have different effects on the economy, in particular on inflation and loans. In addition, the two shocks lead to different reactions of monetary and macroprudential policies. As a result, the volatility of macroeconomic variables differs across shocks and policy rules. In particular, augmented Taylor rules increase the volatility of loans after an intangible productivity shock and, from this perspective, appear to be less desirable than macroprudential rules after this type of shock. However, welfare effects of different policy rules are not qualitatively different across shocks because of similar impacts on the volatility of consumption.

Keywords: Intangible Capital, Monetary Policy, Macroprudential Policy

JEL Classification: E22, E44, E52

I. Introduction

The importance of intangible capital such as software, research and development (R&D), or organizational capital has been increasing in the last few dec-

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ades. The literature emphasizes two important features of intangible capital. First, it can be used simultaneously to produce different goods, and second, it is less suitable than tangible capital as collateral for obtaining external funds. These special characteristics of intangible capital raise the question: Does the presence of this type of capital affect the transmission channels of monetary and macroprudential policies? In this study, we use a dynamic stochastic general equilibrium (DSGE) model with intangible capital and a banking sector to study the effects of monetary and macroprudential policies. We contribute to a growing literature that investigates whether monetary and macroprudential policies can mitigate the instabilities stemming from the financial sector; if so, policy reaction functions should be complemented with targets for financial measures such as the evolution of loans. Researchers have analyzed the effects of such augmented Taylor rules and macroprudential tools in theoretical and empirical studies and investigated the interactions between monetary and macroprudential policies.[1] Our study is related to the subset of this literature on financial frictions and various policy rules in a DSGE framework. We examine whether a model including intangible capital affects the economic implications of monetary and macroprudential policies. In doing this, our paper is also related to the previous literature on the economic effects of intangible capital within a DSGE framework[2] and extends this literature in two respects. First, while the previous literature has mostly focused on the non-pledgeability of intangible capital, we also focus on another important characteristic of intangible capital that allows it to be simultaneously used to produce different goods. Second, we focus our analysis on monetary and macroprudential policies in an intangible economy and put less emphasis than other studies on additional aspects such as labor market dynamics.

In general, intangible capital formation can be interpreted as strategic investments in the long-term growth of companies and the economy. In a narrow sense, intangible investments include intellectual property products (software, R&D, and entertainment, literary, and artistic originals), which are now included in the System of National Accounts. In a broader sense, intangibles additionally include organizational capital, business expenditures on market development, and managerial expertise.[3] If we consider the broad definition of intangibles, firms in many advanced economies invest more in intangible capital than in tangible capital. We model intangible capital in this paper by following

[1] Only a subset of the huge literature can be cited here. For example, *Bernanke* (2011), *Admati* et al. (2010), *Meh/Moran* (2010), *Borio* (2011), *Cecchetti/Kohler* (2012), *Galati/Moessner* (2013), *Lambertini* et al. (2013), *Claessens* (2015), *Cerutti* et al. (2017), *Galati/Moessner* (2018), *Svensson* (2018), and *Bekiros* et al. (2018).

[2] See, e.g., *Perez-Orive* (2016) or *Lopez/Olivella* (2018).

[3] For an overview, see *Corrado* et al. (2009), *Corrado* et al. (2013), *Corrado* et al. (2016), or *Haskel/Westlake* (2017).

McGrattan/Prescott (2010, 2014), which implies that intangible capital can be simultaneously used to produce new tangible and intangible goods. In our model, entrepreneurs invest in physical and intangible capital. Crucially, we assume that they cannot use intangible capital as collateral to borrow from banks. Studies have repeatedly stressed that intangible capital such as R&D is more difficult than tangible capital to use as collateral to obtain external financing, mainly because tangible assets can be better seized in case of default (e.g., *Hall/Lerner* 2010 or *Becker* 2013). Provided that tangible capital can be better used as collateral, an increase in the importance of intangible capital reduces the access of firms to outside financing and could potentially affect the transmission channels of monetary and macroprudential policies. Our modeling of the banking sector is similar to that in *Gambacorta/Signoretti* (2014), where a simplified version of *Gerali* et al. (2010) is used. In particular, loan spreads depend endogenously on the leverage of banks. Because of this endogenous spread, a bank lending channel arises, which opens up a possibility for the central bank and macroprudential authorities to intervene and influence the evolution of financial variables.

Within our framework, we examine the economic effects of augmented Taylor and macroprudential rules. As to monetary policy, we augment a standard Taylor rule with a reaction to the evolution of bank loans. Regarding macroprudential policy, we focus on two (out of several) instruments that our model is suitable to analyze. One instrument, which has gained considerable attention, is targeted towards financial institutions and implements countercyclical capital buffers (e.g., *Drehmann* et al. 2010; *Brei/Gambacorta* 2014). The other instrument is targeted toward borrowers and uses the loan-to-value (LTV) ratio as a policy instrument (e.g., *Claessens* 2015). Both macroprudential rules react to the evolution of loans. In our analysis, we first investigate the effects of sector-specific productivity shocks, that is, shocks to tangible and intangible production. We find that the two sector-specific shocks have different effects on economic variables and the financial system. Under a standard Taylor rule, a positive shock to the productivity of tangible production reduces inflation and increases loans – a result also obtained by conventional models with only tangible goods. By contrast, a productivity shock to intangible production leads to a short-run increase in inflation because intangible productivity shock raises aggregate income leading to higher aggregate consumer demand for tangible goods. Because no productivity shock occurred in the tangible sector, the higher demand leads to higher inflation. Capital investment will be biased toward intangibles, which has a dampening effect on the demand for loans because intangibles cannot be used as collateral. Over the medium-term, the initial intangible productivity shock feeds through the economy and leads to decreasing prices, higher tangible investment, and gradually higher corporate debt.

We then investigate the effects of augmented Taylor rules and macroprudential policies that react to the evolution of loans. In particular, we examine the effects of these rules on macroeconomic stabilization and welfare. Our results suggest that the nature of the productivity shock and the choice of policy rules affect the volatility of macroeconomic variables and, from this perspective, should influence the decision regarding the appropriate rules framework. In particular, augmented Taylor rules increase loan volatility after intangible productivity shocks (and decrease loan volatility after standard tangible shocks), which questions the suitability of this rule if there are intangible productivity shocks in an economy. This result is not surprising in the context of the aforementioned differences in the impulse response functions after the two sector-specific shocks. In terms of welfare, however, our simulation results do not imply qualitative differences across the two productivity shocks because of similar impacts on the volatility of consumption. An augmented Taylor rule delivers better results than a standard Taylor rule for both types of shocks. Macroprudential rules appear to be less desirable in terms of total welfare than standard and augmented Taylor rules. Importantly, for both types of productivity shocks, the same distributional conflicts emerge between entrepreneurs (who borrow and invest) and workers (who save). Augmented Taylor rules are associated with lower volatility of consumption of savers than macroprudential rules are and appear to be desirable for savers from a welfare perspective. For entrepreneurs, however, the volatility of consumption is lower under macroprudential rules than augmented Taylor rules and are therefore desirable to them from a welfare perspective. Based on these welfare results, policy-makers would not need to distinguish between tangible and intangible shocks. However, only focusing on welfare masks the aforementioned effects of policy rules on macroeconomic variables and their volatility across the two productivity shocks.

The remainder of this paper is organized as follows. Section 2 develops a DSGE model with two sectors: one producing tangible goods and the other delivering intangibles. Further, a banking sector is added to the model. Section 3 outlines the calibration strategy, and in Section 4, we present the results of our simulations and investigate the quantitative findings of our model. Section 5 concludes the paper.

II. Model

There are two types of individuals in our model. Patient households work in the tangible and intangible goods sectors and are savers. Impatient entrepreneurs invest in tangible and intangible capital. They can borrow funds from financial intermediaries to finance tangible investment. However, they face borrowing constraints. Intangible investment has to be financed by entrepreneurs out of retained earnings. As elaborated below, financial intermediaries operate in a monopolistically competitive environment channeling the savings of patient individuals to entrepreneurs.

1. Patient Households

Patient individuals maximize a standard utility function

$$E_t \left\{ \sum_{t=0}^{\infty} \left(\beta^p\right)^t \left(\ln c_t^p - \psi \frac{h_t^{1+\nu}}{1+\nu} \right) \right\} \tag{1}$$

where c_t^p is consumption, h_t is hours worked and the preference parameters β^p, ψ, and ν are positive. $E_t \{\}$ denotes the expectation operator. The budget constraint is given by the following expression in nominal terms

$$P_t d_t + P_t c_t^p = P_{t-1}\left(1 + r_{t-1}^d\right) d_{t-1} + P_t w_t h_t \tag{2}$$

where d_t is the amount of real savings deposits, r_t^d is the interest rate, w_t is the wage rate, and P_t is the consumer goods price index. In real terms, this constraint can be written as

$$d_t + c_t^p = \frac{\left(1 + r_{t-1}^d\right) d_{t-1}}{\Pi_t} + w_t h_t \tag{3}$$

where Π_t denotes gross inflation. The maximization problem for patient individuals is then given by

$$\max_{c_t^p,\, h_t,\, d_t} E_t \left\{ \sum_{t=0}^{\infty} \left(\beta^p\right)^t \left[\ln c_t^p - \psi \frac{h_t^{1+\nu}}{1+\nu} - \lambda_t^0 \left(d_t + c_t^p - \frac{\left(1 + r_{t-1}^d\right) d_{t-1}}{\Pi_t} - w_t h_t \right) \right] \right\}$$

where λ_t^0 is the Lagrange multiplier. The first order conditions with respect to $\left\{c_t^p, h_t, d_t\right\}$ are

$$\frac{1}{c_t^p} = \lambda_t^0 \tag{4}$$

$$\psi h_t^\nu = \lambda_t^0 w_t \tag{5}$$

$$\beta^p \left(1 + r_t^d\right) E_t \left\{ \frac{\lambda_{t+1}^0}{\Pi_{t+1}} \right\} = \lambda_t^0 \tag{6}$$

2. Entrepreneurs

Entrepreneurs choose their level of consumption c_t^e and invest in tangible and intangible capital (k_t^T and k_t^I). They can borrow at the interest rate r_t^b from financial intermediaries. Their borrowing constraint is determined by the amount of tangible capital. The utility function of entrepreneurs is given by

$$E_t \left\{ \sum\nolimits_{t=0}^{\infty} (\beta^e)^t \ln c_t^e \right\} \tag{7}$$

where the discount factor β^e is assumed to be lower than for patient individuals. This utility function is maximized subject to the budget constraint

$$\begin{aligned} &P_t c_t^e + P_t x_{T,t} + Q_t x_{I,t} + P_{t-1} b_{t-1} \left(1 + r_{t-1}^b\right) = \\ &P_t r_{T,t} k_{T,t} + P_t r_{I,t} k_{I,t} + P_t b_t + Pr_t \end{aligned} \tag{8}$$

where $x_{T,t}$ is investment in tangible capital. $x_{I,t}$ is intangible investment and Q_t is its nominal price. The rates of return on tangible and intangible capital are denoted by $r_{T,t}$ and $r_{I,t}$, respectively. The capital stocks depreciate at rates δ_T and δ_I for tangible and intangible capital, respectively. Pr_t captures profits from tangible and intangible production not directly attributed to capital. Borrowing is denoted by b_t and is constrained by $b_t \leq \dfrac{m E_t \left\{\Pi_{t+1} k_{T,t+1}\right\}}{1 + r_t^b}$. The parameter m governs the LTV ratio. Adding convex adjustment costs for investment (determined by ψ_{k_T} and ψ_{k_I}), the laws of motion for tangible and intangible capital are given by

$$k_{T,t+1} = x_{T,t} - \frac{\psi_{k_T}}{2} \left(\frac{x_{T,t}}{k_{T,t}} - \delta_T \right)^2 k_{T,t} + (1 - \delta_T) k_{T,t} \tag{9}$$

$$k_{I,t+1} = x_{I,t} - \frac{\psi_{k_I}}{2} \left(\frac{x_{I,t}}{k_{I,t}} - \delta_I \right)^2 k_{I,t} + (1 - \delta_I) k_{I,t}\,. \tag{10}$$

Total hours worked h_t are composed of hours worked for tangible output h_t^1 and hours worked to produce intangible output . Dividing by P_t, we can express the constraints of the entrepreneur in real terms

$$\frac{\left(1 + r_{t-1}^b\right) b_{t-1}}{\Pi_t} + x_{T,t} + q_t x_{I,t} + c_t^e = b_t + r_{T,t} k_{T,t} + r_{I,t} k_{I,t} + \frac{Pr_t}{P_t} \tag{11}$$

$$x_{T,t} = k_{T,t+1} - (1 - \delta_T) k_{T,t} + \frac{\psi_{k_T}}{2} \left(\frac{x_{T,t}}{k_{T,t}} - \delta_T \right)^2 k_{T,t} \tag{12}$$

$$x_{I,t} = k_{I,t+1} - (1-\delta_I)k_{I,t} + \frac{\psi_{k_I}}{2}\left(\frac{x_{I,t}}{k_{I,t}} - \delta_I\right)^2 k_{I,t} \tag{13}$$

$$(1+r_t^b)b_t \le mE_t\{\Pi_{t+1}k_{T,t+1}\} \tag{14}$$

where $q_t = Q_t / P_t$ is the relative price of intangible capital. The first-order conditions with respect to $\{c_t^e, b_t, x_{T,t}, x_{I,t}, k_{T,t+1}, k_{I,t+1}\}$ are then given by[4]

$$\frac{1}{c_t^e} = \lambda_t^1 \tag{15}$$

$$\beta^e(1+r_t^b)E_t\left\{\frac{\lambda_{t+1}^1}{\Pi_{t+1}}\right\} + \lambda_t^4(1+r_t^b) = \lambda_t^1 \tag{16}$$

$$\lambda_t^1 = \lambda_t^2\left[1 - \psi_{k_T}\left(\frac{x_{T,t}}{k_{T,t}} - \delta_T\right)\right] \tag{17}$$

$$\lambda_t^1 q_t = \lambda_t^3\left[1 - \psi_{k_I}\left(\frac{x_{I,t}}{k_{I,t}} - \delta_I\right)\right] \tag{18}$$

$$\lambda_t^2 = \beta^e E_t\left\{\lambda_{t+1}^1 r_{T,t+1} + \lambda_{t+1}^2\left(1 - \delta_T + \frac{\psi_{k_T}}{2}\left(\frac{x_{T,t+1}^2}{k_{T,t+1}^2} - \delta_T^2\right)\right)\right\} + \lambda_t^4 mE_t\{\Pi_{t+1}\} \tag{19}$$

$$\lambda_t^3 = \beta^e E_t\left\{\lambda_{t+1}^1 r_{I,t+1} + \lambda_{t+1}^3\left(1 - \delta_I + \frac{\psi_{k_I}}{2}\left(\frac{x_{I,t+1}^2}{k_{I,t+1}^2} - \delta_I^2\right)\right)\right\} \tag{20}$$

3. *Firms*

Tangible and intangible goods are produced by a continuum of firms, each of which has local monopoly power. An intermediate firm $i \in (0,1)$ uses two constant returns to scale technologies to produce tangible and intangible goods. Firms produce tangible output $y_t(i)$ with tangible capital $k_{T,t}^1(i)$, intangible capital $k_{I,t}(i)$, and labor $h_t^1(i)$. Firms also produce intangible output $x_{I,t}(i)$ –such as software, R&D, brands, or organization capital – using tangible capital $k_{T,t}^2(i)$, intangible capital $k_{I,t}(i)$, and labor $h_t^2(i)$. The intangible characteristic of $k_{I,t}(i)$ makes it possible for the total stock of intangible capital to be simultaneously used as an input in both business sectors as in *McGrattan/Prescott* (2014). In the following, we drop the index *i* where appropriate to simplify the exposition. The two production functions are given by

[4] We denote by $\lambda_t^1, \lambda_t^2, \lambda_t^3$, and λ_t^4 the Lagrange multipliers for the four constraints.

(21) $$y_t = A_t^1 \left(k_{T,t}^1\right)^{\theta} \left(k_{I,t}\right)^{\phi} \left(h_t^1\right)^{1-\theta-\phi}$$

(22) $$x_{I,t} = A_t^2 \left(k_{T,t}^2\right)^{\theta} \left(k_{I,t}\right)^{\phi} \left(h_t^2\right)^{1-\theta-\phi}.$$

where y_t is used to satisfy consumer demand and tangible investment. Note that $h_t = h_t^1 + h_t^2$ and the patient individual receives the same wage for the two types of labor. The sector-specific technology variables A_t^1 and A_t^2 follow AR(1)-processes of the following types

$$\ln A_{t+1}^1 = \rho^{A^1} \ln A_t^1 + \left(1 - \rho^{A^1}\right) \ln A^1 + \in_{t+1}^{A^1}$$

$$\ln A_{t+1}^2 = \rho^{A^2} \ln A_t^2 + \left(1 - \rho^{A^2}\right) \ln A^2 + \in_{t+1}^{A^2}$$

The parameters ρ^{A^1} and ρ^{A^2} govern the persistence of these processes. $\in_{t+1}^{A^1}$ and $\in_{t+1}^{A^2}$ denote the two sector-specific technology shocks. Firms minimize real costs subject to the production functions

$$\min_{k_{T,t}^1, k_{T,t}^2, k_{I,t}, h_t^1, h_t^2} r_{T,t}\left(k_{T,t}^1 + k_{T,t}^2\right) + r_{I,t} k_{I,t} + w_t\left(h_t^1 + h_t^2\right)$$

$$-mc_t^1\left(A_t^1 (k_{T,t}^1)^{\theta} (k_{I,t})^{\phi} (h_t^1)^{1-\theta-\phi} - y_t\right)$$

$$-mc_t^2 q_t\left(A_t^2 (k_{T,t}^2)^{\theta} (k_{I,t})^{\phi} (h_t^2)^{1-\theta-\phi} - x_{I,t}\right)$$

Cost minimization is complicated because the firm uses two different production functions. Moreover, the same stock of intangible capital appears in both production functions. The first order conditions with respect to $\left\{k_{T,t}^1, k_{T,t}^2, k_{I,t}, h_t^1, h_t^2\right\}$ are given by

(23) $$r_{T,t} = \frac{mc_t^1 y_t}{k_{T,t}^1}$$

(24) $$r_{T,t} = \theta \frac{mc_t^2 q_t x_{I,t}}{k_{T,t}^2}$$

(25) $$r_{I,t} = \frac{\phi mc_t^1 y_t + \phi mc_t^2 q_t x_{I,t}}{k_{I,t}}$$

(26) $$w_t = (1 - \theta - \phi) \frac{mc_t^1 y_t}{h_t^1}$$

(27) $$w_t = (1-\theta-\phi)\frac{mc_t^2 q_t x_{I,t}}{h_t^2}$$

We follow *Calvo* (1983) in assuming that firms cannot flexibly set their prices. In each period, a firm has the opportunity to adjust its prices; an event that occurs with the probability $1-\in$ for tangible prices and $1-\xi$ for intangible prices. When the firm does not reset its price, it applies the price it charged in the preceding period such that $P_t(i) = P_{t-1}(i)$ and $Q_t(i) = Q_{t-1}(i)$. When it has an opportunity to reset, firm *i* chooses its optimal prices $P_t(i)^*$ and $Q_t(i)^*$ in period *t* to maximize the expected discounted profit flow generated by these new prices. The expected profit flow is maximized subject to standard expressions for demand

$$y_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\omega_1} y_t$$

and

$$x_{I,t}(i) = \left(\frac{Q_t(i)}{Q_t}\right)^{-\omega_2} x_{It}\,.$$

This leads to the price-setting equations

$$E_t\left\{\sum_{j=0}^{\infty}(\beta^e \in)^j \frac{\lambda_{t+j}^0}{\lambda_t^0}\left((1-\omega_1)\left(\frac{P_t^*(i)}{P_{t+j}}\right)^{-\omega_1} y_{t+j} + \omega_1 \frac{P_{t+j}}{P_{t+j}(i)}\left(\frac{P_t^*(i)}{P_{t+j}}\right)^{-\omega_1} mc_{t+j}^1 y_{t+j}\right)\right\} = 0$$

and

$$E_t\left\{\sum_{j=0}^{\infty}(\beta^e \xi)^j \frac{\Lambda_{t+j}^0}{\Lambda_t^0}\left((1-\omega_2)\left(\frac{Q_t^*(i)}{Q_{t+j}}\right)^{-\omega_2} x_{I,t+j} + \omega_2 \frac{Q_{t+j}}{Q_{t+j}(i)}\left(\frac{Q_t^*(i)}{Q_{t+j}}\right)^{-\omega_2} mc_{t+j}^2 x_{I,t+j}\right)\right\} = 0$$

All firms that reset their prices in period *t* set them at the same level. This implies the following expressions

$$P_t^* = \frac{A_t}{B_t}$$

and

$$Q_t^* = \frac{C_t}{D_t},$$

where A_t, B_t, C_t, and D_t are defined as

(28) $$A_t = E_t \left\{ \frac{\omega_1}{\omega_1 - 1} \lambda^0_{t+j} P_t^{1+\omega_1} mc_t^1 y_t + \beta^e \in A_{t+1} \right\}$$

(29) $$B_t = E_t \left\{ \lambda^0_{t+j} P_t^{\omega_1} y_t + \beta^e \in B_{t+1} \right\}$$

and

(30) $$C_t = E_t \left\{ \frac{\omega_2}{\omega_2 - 1} \lambda^0_{t+j} Q_t^{1+\omega_2} mc_t^2 x_{It} + \beta^e \xi C_{t+1} \right\}$$

(31) $$D_t = E_t \left\{ \lambda^0_{t+j} Q_t^{\omega_2} x_{It} + \beta^e \xi D_{t+1} \right\}$$

The price indices are given by

$$P_t = \left(\int_0^1 P_t(i)^{1-\omega_1} di \right)^{\frac{1}{1-\omega_1}}$$

and

$$Q_t = \left(\int_0^1 Q_t(i)^{1-\omega_2} di \right)^{\frac{1}{1-\omega_2}}$$

These indices comprise surviving contracts and newly set prices. In each period, the probability that a tangible output price contract will end is $1-\in$ and that of an intangible output price contract is $1-\xi$. Then, the aggregate price levels can be expressed recursively as

(32) $$P_t = \left((1-\in) P_t^{*1-\omega_1} + \in P_{t-1}^{1-\omega_1} \right)^{\frac{1}{1-\omega_1}}$$

and

(33) $$Q_t = \left((1-\xi) P_t^{*1-\omega_2} + \xi P_{t-1}^{1-\omega_2} \right)^{\frac{1}{1-\omega_2}}$$

4. *Banking Sector*

The modeling of the banking sector closely follows the approach in *Gambacorta/Signoretti* (2014), which is a simplified version of *Gerali* et al. (2010). The banking sector comprises a wholesale branch and a retail branch. The wholesale branch collects deposits d_t from households and pays an interest rate r_t^d on these deposits. This interest rate is equal to the interest rate on the interbank market and is assumed to be determined by the central bank. Therefore, the wholesale deposit rate is equal to the policy rate r_t. Further, the wholesale branch issues wholesale loans b_t at the interest rate R_t^b. The retail banks buy wholesale loans, differentiate them at no cost and resell them to final borrowers. Each unit charges a fixed markup μ on the wholesale loan rate to determine the retail loan rate. The loan rate for entrepreneurs is thus given by $r_t^b = R_t^b + \mu$.

The wholesale branch has a target leverage ratio ν^b determined by macroprudential policy and pays a cost for deviating from that target. This implies that the degree of leverage influences the interest rate on loans. Developments in the real economy affect bank profits, bank leverage and the financing conditions of borrowers. Bank profits comprise the net interest margin (loan minus deposit interest payments) minus the (quadratic) cost that the bank has to pay for deviating from its target leverage ν^b. This cost is parametrized by κ_{k^b}. The leverage of the wholesale branch is accumulated by its own funds k_t^b that are accumulated out of reinvested profits

(34) $$\Pi_t k_t^b = (1-\delta^b) k_{t-1}^b + j_{t-1}^b,$$

where j_t^b are overall real profits made by the branches of each bank and δ^b measures the resources used in managing the bank capital. In the wholesale branch, b_t and d_t are chosen to maximize profits subject to a balance-sheet constraint

(35) $$\max_{b_t, d_t} R_t^b b_t - R_t^d d_t - \frac{\kappa_{k^b}}{2}\left(\frac{k_t^b}{b_t} - \nu^b\right)^2 k_t^b$$

(36) $$b_t = d_t + k_t^b$$

The first-order conditions for a wholesale branch yield a condition linking the spread between wholesale rates on loans and deposits to the deviations from the targeted inverse of the leverage ratio k_t^b / b_t

(37) $$R_t^b = r_t^d - \kappa_{k^b}\left(\frac{k_t^b}{b_t} - \nu^b\right)\left(\frac{k_t^b}{b_t}\right)^2$$

This equation implies that the interest rate on loans equals the policy rate plus a spread that depends on the bank leverage.

5. *Central Bank and Macroprudential Policy*

We consider several versions of Taylor rules. In the baseline case, the central bank follows a simple standard Taylor rule and reacts only to consumer price inflation

$$\ln(R_t) = \rho_r \ln(R_{t-1}) + (1-\rho_r)\ln(R) + \gamma_\pi (\ln(\pi_t) - \ln(\pi)) \tag{38}$$

Variables without a time index are steady states. As discussed in the introduction, we then consider an augmented version of a Taylor rule, where the central bank reacts to the deviations in loans (b_t) from its steady-state value

$$\ln(R_t) = \rho_r \ln(R_{t-1}) + (1-\rho_r)\ln(R) + \gamma_\pi (\ln(\pi_t) - \ln(\pi)) + \gamma_b (\ln(b_t) - \ln(b)) \tag{39}$$

Further, we investigate the effects of the two macroprudential rules as discussed in the introduction. In the first rule, the authorities adopt a countercyclical rule for the leverage ratio. v_t^b then becomes a variable and reacts to the evolution of loans according to the following expression

$$v_t^b = \rho_v v_{t-1}^b + (1-\rho_v) v^b + \tau_v (\log(b_t) - \log(b)) \tag{40}$$

Next, we consider a rule where macroprudential authorities adjust the LTV ratio to deviations in loans from its steady-state value

$$m_t = (1-\rho_m) m + \rho_m m_{t-1} - \tau_m (\log(b_t) - \log(b)) \tag{41}$$

III. Choice of Parameter Values

The model is solved using a second-order approximation around the non-stochastic steady state.[5] Table 1 depicts the chosen parameter values for our simulation exercises. We aim to be close to standard parameters in the literature. Note that one period corresponds to one quarter. For the shares of tangible and intangible capital in production, we mainly draw from the values used by *McGrattan/Prescott* (2012) or *Corrado* et al. (2009). We set the share of tangible capital θ at 0.2 and the share of intangible capital ϕ at 0.15. This captures the fact that intangible capital, when defined broadly, is almost as important as tangible capital in advanced economies. Thus, 0.65 remains for the labor income share of total output. In sensitivity analyses, we assume $\theta = 0.25$ and $\phi = 0.1$. The value of ψ is chosen such that $h = 1/3$ in steady-state. Following *McGrattan/Prescott* (2012), we set the depreciation rate of intangible capital equal to that of tangible capital and choose standard values at 0.025. The literature on intangible investments has emphasized that different forms of intangible capital could be associated with different depreciation rates. However, our qualitative results do not hinge on reasonable variations in depreciation rates. For the parameter values related to the financial sector, we follow the values suggested by *Gerali* et al. (2010) and *Gambacorta/Signoretti* (2014). The adjustment cost pa-

[5] Dynare version 4.5.7 is used to derive the quantitative findings in this study.

Table 1

Choice of Parameter Values

Parameter	*Value*	*Parameter*	*Value*
β^p	0.996	δ_T	0.025
β^e	0.997	δ_I	0.025
ψ	6.635	m	0.35
θ	0.20	δ^b	0.049
ϕ	0.15	K_{k^b}	11
χ	6	v^b	0.09
υ	1	ρ_r	0.80
ξ	0.75	γ_π	1.50
$\in$	0.75	γ_b	0.5
ω_1	6	τ_v	0.5
ω_2	6	τ_m	0.5
ρ^{A1}	0.90	ρ_m	0.8
ρ^{A2}	0.90	ρ_v	0.8

rameter for tangible capital ψ_{k_T} is set to match the standard deviation of tangible investment relative to GDP in advanced economies, which is approximately 3.0. For intangible capital, the choice is more difficult, particularly because quarterly data for our broad definition of intangible capital are not available. We use the same value for the adjustment cost parameters as for tangible capital, which allows us to focus on the difference between tangible and intangible capital in the production process.

The standard deviations of the two technology shocks are set to achieve a relative standard deviation of A_t^1 and A_t^2 of 2.0. In our model variants, this yields a standard deviation of output of approximately 1.8–2.0 for tangible goods after a shock to A_t^1, which is consistent with the standard deviation found in the data. The price stickiness parameters are set at 0.75. The Taylor rule coefficients in the baseline case take standard values, $\rho_r = 0.8$ and $\gamma_\pi = 1.5$. For the augmented rule, we assume $\gamma_b = 0.5$ in the baseline version, but also experiment with different values. For the macroprudential rules, we choose in the baseline versions: $\rho_m = 0.8, \rho_v = 0.8, \tau_v = 0.5$ and $\tau_m = 0.5$.

IV. Quantitative Findings

1. Impulse Response Functions

This section presents impulse response functions for productivity shocks to tangible and intangible production. In particular, we investigate how monetary and macroprudential policy rules affect the evolution of the variables in our model. For the real variables, we show the response of tangible output (tang out), intangible output (int out), and consumption of patient (cp) and impatient (ce) individuals. As regards the nominal variables, we show impulse responses for the prices of tangible and intangible goods (P and Q), loans (b), the leverage ratio (lev), the central bank interest rate (rd), and the interest rate that applies to entrepreneurs (rb).

Figures 1 to 3 depict the effects of productivity shocks to tangible and intangible production. In these baseline simulations, we consider a basic Taylor rule where the central bank only reacts to consumer price inflation. For a tangible productivity shock, the output of both types of goods and consumption increase while inflation decreases, which is a standard result that could also be obtained by conventional models with only tangible capital (Figure 1). This induces the central bank to reduce its interest rates. As for the banking system, there is an increase in loans after a productivity shock to tangible production, which is stronger than the increase in bank capital. Consequently, there is a rise in the leverage ratio. Importantly, a productivity shock to intangible production has different effects on our model economy than a tangible productivity shock (Figure 2). For this productivity shock, inflation modestly rises in the first periods for both tangible and intangible goods before it turns negative. The reason for this pattern is that the higher aggregate income after the intangible productivity shock increases overall consumption demand for tangible output, where no productivity shock occurred. This leads to higher prices in the tangible sector. Higher demand for tangible output also stimulates demand for intangible capital and drives its price up in the short term. After an intangible productivity shock, capital investment is biased toward intangibles, which dampens the demand for loans, because intangibles cannot be used as collateral in our model. Higher inflation initially induces the central bank to increase its interest rates. This pattern is qualitatively different from the case of a productivity shock to tangible production where both inflation and interest rates decrease. In the medium-term, the intangible productivity shock feeds through the economy and lowers the price level. Additionally, the amount of loans will in the medium-term moderately increase above the steady-state level after the initial decrease. Tracking the evolution of loans, the leverage ratio initially decreases after an intangible shock, but increases above its steady-state value in the medium term when the intangible productivity shock has fed through the economy. We then decrease the importance of intangible capital by setting $\phi = 0.1$ and show that the responses of the variables to an intangible productivity shock are more pronounced when intangible production is more important (Figure 3). When the importance of intangible capital is higher, inflation increases more because the demand for tangible goods is stimulated more. This induces the central bank to raise interest rates more aggressively.

We now investigate whether the various monetary and macroprudential rules affect the evolution of economic variables differently across the two shocks. Figures 4 to 9 show the impact of an augmented Taylor rule and the two versions of macroprudential rules on the response of the variables after tangible and intangible productivity shocks. In Figures 4 and 5, we compare the effects of a standard Taylor rule to the effects of a central bank that uses an augmented Taylor rule with a reaction to the evolution of loans. For the case of a productivity shock to tangible output, a central bank using an augmented Taylor rule increases its interest rates after an initial decrease instead of a persistent reduction under the standard rule (Figure 4). This occurs because the central bank reacts to the rise in loans after a tangible productivity shock. As a result of the increased aggressiveness of the central bank, inflation decreases more under the augmented rules than under the standard rule. As one might expect, the central bank successfully mitigates loan growth rates under the augmented Taylor rule. Interestingly, for a productivity shock to intangible production, the response of the interest rate becomes somewhat more volatile when the central bank reacts to loan growth (Figure 5). The interest rate first slightly decreases as the central bank reacts to the initial negative growth rate of loans. In the medium term, however, the interest rate increases more than under a standard Taylor rule following the gradual expansion of loans.

In Figures 6 and 7, the augmented Taylor rule is compared to a macroprudential rule, where the targeted LTV ratio reacts to the evolution of loans. For this first macroprudential rule, we observe that for both a tangible and an intangible productivity shock, the responses of loans and the leverage ratio are considerably dampened compared to an augmented Taylor rule. As a whole, there is considerably less volatility in the financial sector under this macroprudential rule than under an augmented Taylor rule. The evolution of output in both sectors is very similar across the two rules, but inflation is higher (or deflation lower) for the LTV rule. In Figures 8 and 9, the effects of a macroprudential rule are analyzed where the targeted leverage ratio reacts to loans. In the case of intangible productivity shocks, this macroprudential rule is associated with a more volatile reaction of the leverage ratio and a more volatile interest rate on loans. The evolution of output is similar to that of an augmented Taylor rule. After a tangible productivity shock, the leverage ratio significantly decreases. As a result, the interest rate on loans considerably increases, and output expansion in both sectors is slightly dampened. Importantly, for both types of shocks, consumption of savers is more volatile under the two macroprudential rules than under the augmented Taylor rule but is less volatile for entrepreneurs (who are the borrowers). These findings have important implications for our following welfare analyses. In addition, because the central bank reacts less aggressively, inflation is higher (or deflation lower) under the two macroprudential rules.

2. Macroeconomic Stability and Welfare

We now investigate whether monetary and macroprudential policies can improve upon standard Taylor rules in terms of macroeconomic stabilization and social welfare. Regarding macroeconomic stabilization, we report the volatility of output, inflation and loans. The computation of welfare gains and losses follows the literature. Welfare levels for the patient individual and the entrepreneur are given by:

(42) $$W_t^p = E_t \left\{ \sum_{t=0}^{\infty} (\beta^p)^t \left(\ln c_t^p - \psi \frac{h_t^{1+\nu}}{1+\nu} \right) \right\}$$

(43) $$W_t^e = E_t \left\{ \sum_{t=0}^{\infty} (\beta^e)^t \ln c_t^e \right\}$$

To compute welfare gains and losses, we take a second-order approximation and simulate the model for 50,000 periods. In addition to the levels of welfare, we obtain the welfare loss (or gain) in terms of consumption with respect to the steady-state's welfare. Additionally, we compute the total welfare W_t^T as a weighted average of the welfare levels of the two types, where the weights are chosen in the standard manner used in the literature (e.g., *Rubio* 2011).

(44) $$W_t^T = (1-\beta^p) W_t^p + (1-\beta^e) W_t^e$$

The findings in Tables 2 and 3 show the volatility of macroeconomic variables and welfare for different Taylor and macroprudential rules. Table 2 shows the results for a tangible productivity shock. The findings for an intangible productivity shock are presented in Table 3. Regarding the macroeconomic variables, we show the volatility of output, inflation and loans (vol out, vol infl, vol loan). We then show the welfare of savers, entrepreneurs and total welfare in levels (wsav, wentr, wtot), as well as welfare changes in consumption equivalents for the two types of individuals (wsavce, wentrece). There are 13 rows, where we vary the parameter values in the monetary and macroprudential rules. In the first row, we show the results for a basic Taylor rule, where the central bank only reacts to inflation. Rows 2–5 of each table show the results for augmented Taylor rules that include a reaction of the central bank to the evolution of loans.

In the rows, we vary the degree of aggressiveness of the reaction. Finally, in rows 6–13, the effects of the two macroprudential rules are studied with varying degrees of responsiveness.

As to the tangible productivity shock, Table 2 shows that all augmented Taylor and macroprudential rules reduce the standard deviation of loans, but increase the standard deviation of inflation when compared to a baseline Taylor rule. Thus, additional policy goals increase the volatility of inflation compared to a situation where the evolution of prices is the only policy goal. The rule involving the loan-to-value ratio most strongly reduces the volatility of loans (*Lambertini* et al. 2013). Compared to the basic Taylor rule, the macroprudential rule targeting the leverage ratio and augmented Taylor rules reduce the volatility of output, and output volatility is higher under a macroprudential rule targeting the loan-to-value ratio. For welfare, we observe that total welfare improves for augmented Taylor rules when compared to a standard rule, whereas both macroprudential rules reduce total welfare. Importantly, distributional conflicts arise between savers and entrepreneurs. For augmented Taylor rules, compared to the standard rule, welfare for savers improves, while the welfare for entrepreneurs deteriorates. This finding is unsurprising because the impulse response function in Figure 4 implies that the consumption of savers is less volatile under augmented Taylor rules, and consumption is more volatile for entrepreneurs. Interestingly, both macroprudential rules have different distributional consequences than augmented Taylor rules: the welfare of savers deteriorates compared to an augmented Taylor rule, and the welfare of entrepreneurs improves. Again, this finding is unsurprising because of the impulse response functions for consumption in Figures 6 and 8.

Table 3 shows the results for productivity shocks to intangible production, which exhibit different effects on macroeconomic volatility than tangible productivity shocks. For intangible shocks, augmented Taylor rules reduce the volatility of inflation, but increase the volatility of output when compared to a standard Taylor rule. In addition, augmented Taylor rules decrease the volatility of loans after tangible shocks, but rise loan volatility after intangible shocks. Thus, for augmented Taylor rules, the aforementioned differences between tangible and intangible productivity shocks translate to qualitatively different effects on macroeconomic volatility. This questions the suitability of augmented Taylor rules after intangible productivity shocks. For macroprudential rules, there are less differences than for augmented Taylor rules across the two shocks. Both macroprudential rules decrease the volatility of loans after an intangible productivity shock, but tend to increase the volatility of output and inflation. However, the distributional welfare implications remain the same as those for the tangible shock mainly because the effects on the volatility of consumption remain similar. A central bank reacting to loans improves the welfare for savers while it decreases welfare for entrepreneurs. When comparing macroprudential rules to augmented Taylor rules, the distributional effects reverse in the same manner as for tangible productivity shocks. Macroprudential rules reduce the welfare of savers, but increase the welfare of entrepreneurs. Based on the welfare results, central banks would not need to identify the nature of the productivity shock because the welfare implications remain similar across the two shocks. However, the volatility of macroeconomic variables differs across shocks and policy rules.

V. Conclusions

This paper has studied the effects of monetary and macroprudential policies in a DSGE model with intangible capital and a banking sector. Sector-specific productivity shocks to tangible and intangible production affect the economy differently. Moreover, augmented Taylor and macroprudential rules do not have the same effects on the real economy and the banking sector after the two productivity shocks. In particular, augmented Taylor rules reduce the volatility of loans in the presence of tangible shocks, but increase the volatility of loans for intangible shocks. Macroprudential rules reduce the volatility of loans for both types of shocks. However, they tend to be associated with increased volatility of inflation and output compared to monetary rules. Regarding welfare, we find that for shocks to both tangible and intangible production, a reaction of the central bank to the evolution of loans leads to lower consumption volatility and higher welfare of savers. For entrepreneurs, augmented Taylor rules increase consumption volatility and deteriorate entrepreneurial welfare. For macroprudential rules, the opposite result emerges. The welfare of savers deteriorates and the welfare for entrepreneurs improves compared to a standard Taylor rule. Therefore, our results suggest that entrepreneurs would favor macroprudential rules for any shock, and savers would favor augmented Taylor rules for any shock. In summary, our results do not imply unambiguous policy recommendations. Although the economic reactions and the volatility of macroeconomic variables may considerably depend on the nature of the productivity shock and the framework of monetary and macroprudential rules, welfare analyses do not reveal qualitative differences.

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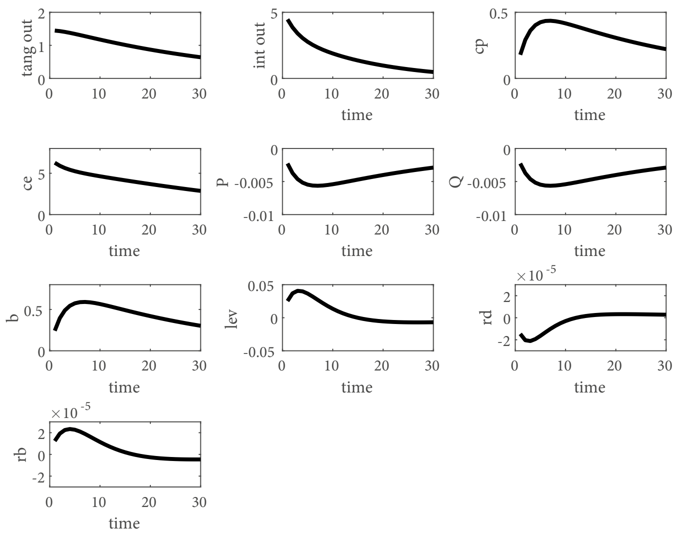


Figure 1: Tangible Shock

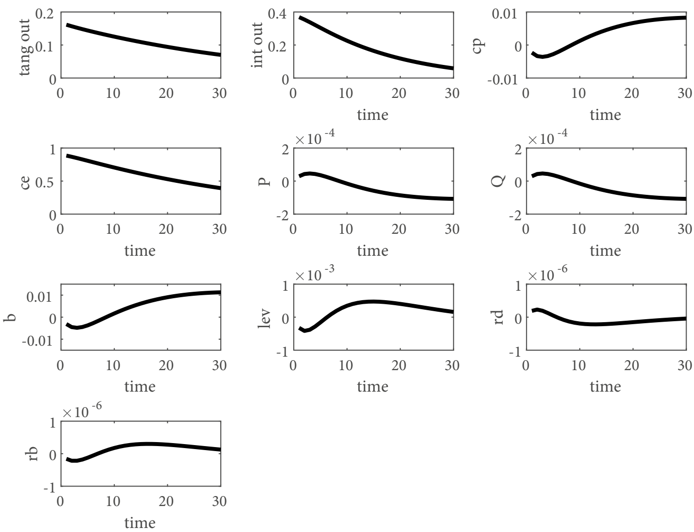
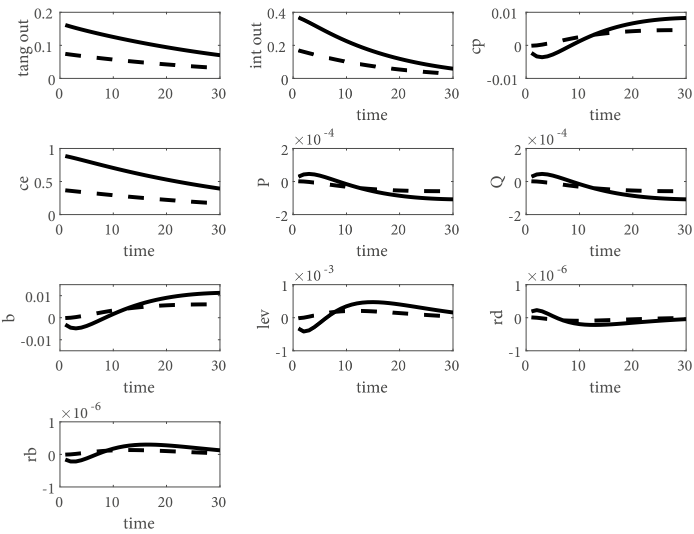
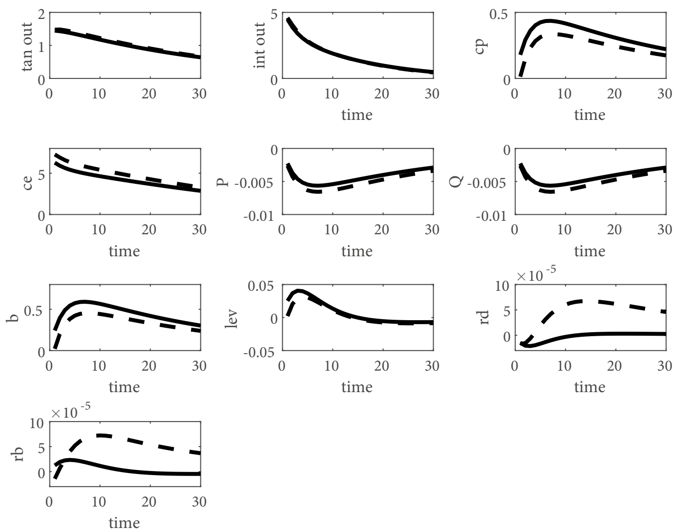


Figure 2: Intangible Shock



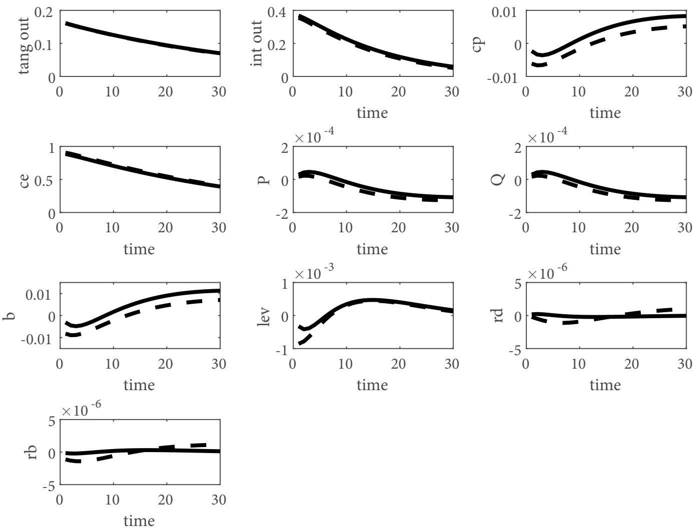
Note: Solid line: baseline intangible share; Dashed line: low intangible share

Figure 3: Intangible Shock with Low Share of Intangibles



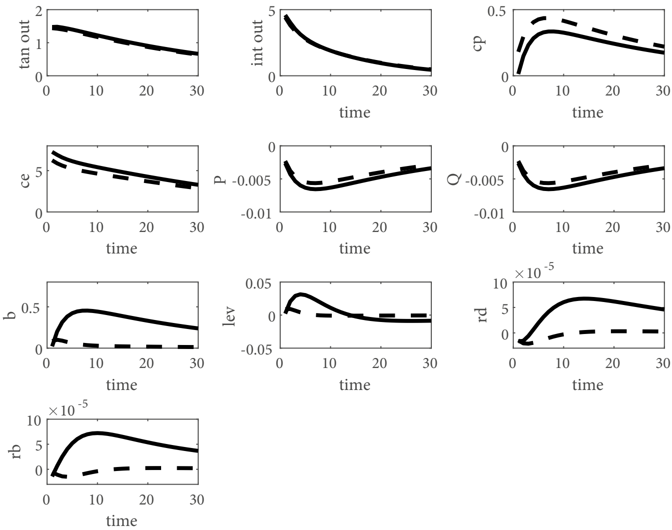
Note: Solid line: Baseline Taylor Rule; Dashed line: Augmented Taylor Rule

Figure 4: Tangible Shock with an Augmented Taylor Rule



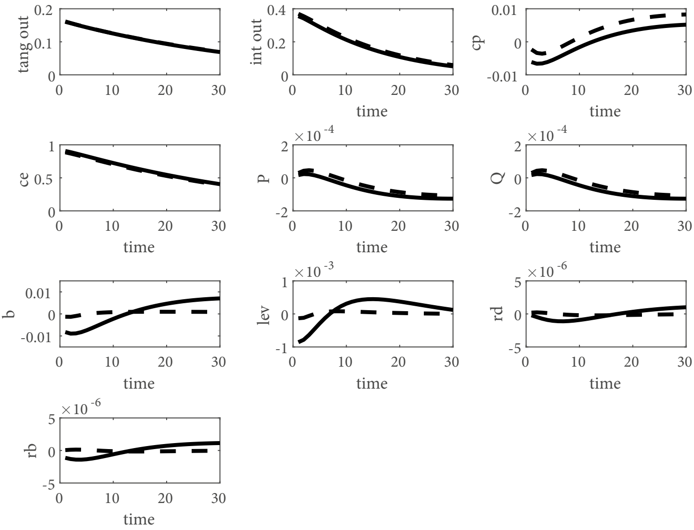
Note: Solid line: Baseline Taylor Rule; Dashed line: Augmented Taylor Rule

Figure 5: Intangible Shock with an Augmented Taylor Rule



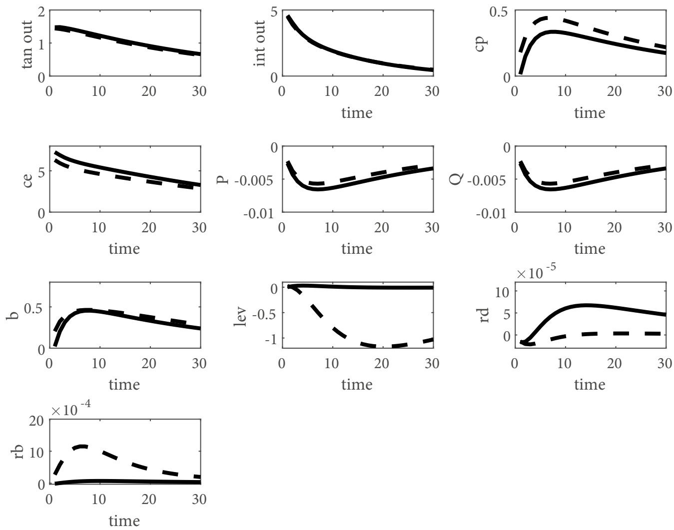
Note: Solid line: Augmented Taylor Rule; Dashed line: LTV Macroprudential Rule

Figure 6: Augmented Taylor Rule and
Loan-to-Value Macroprudential Rule for a Tangible Shock



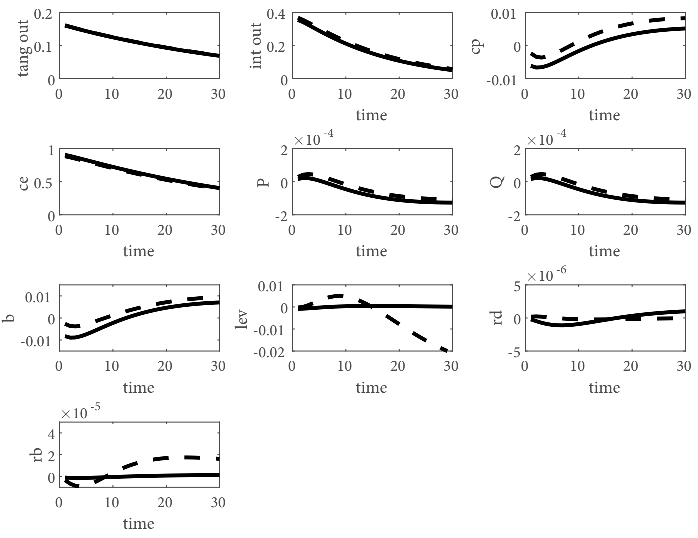
Note: Solid line: Augmented Taylor Rule; Dashed line: LTV Macroprudential Rule

Figure 7: Augmented Taylor Rule and
Loan-to-Value Macroprudential Rule for an Intangible Shock



Note: Solid line: Augmented Taylor Rule; Dashed line: Leverage Ratio Macroprudential Rule

Figure 8: Augmented Taylor Rule and
Leverage Ratio Macroprudential Rule for a Tangible Shock



Note: Solid line: Augmented Taylor Rule; Dashed line: Leverage Ratio Macroprudential Rule

Figure 9: Augmented Taylor Rule and Leverage Ratio Macroprudential Rule for an Intangible Shock

Table 2

Macroeconomic Volatility and Welfare after a Tangible Productivity Shock

	taylor	*prudential*	*vol out*	*vol infl*	*vol loan*	*wsav*	*wentr*	*wtot*	*wsavce*	*wentrece*
Standard Taylor Rule										
1	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8396	0.2795	0.6916	–412.2426	–52.6668	–2.9656	–0.0180	0.0089
Augmented Taylor Rule										
2	$\gamma_\pi = 1.5$, $\gamma_b = 0.25$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8264	0.2956	0.6238	–407.8108	–53.1032	–2.9588	–4.8349e-04	–0.0026
3	$\gamma_\pi = 1.5$, $\gamma_b = 0.5$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8245	0.3097	0.5801	–407.8775	–53.0970	–2.9589	-7.4977e-04	–0.0019
4	$\gamma_\pi = 1.5$, $\gamma_b = 0.75$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8228	0.3219	0.5461	–407.9313	–53.0921	–2.9590	–9.6496e-04	–0.0018
5	$\gamma_\pi = 1.5$, $\gamma_b = 1.0$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8213	0.3328	0.5201	–407.9726	–53.0884	–2.9591	–0.0011	–0.0017
Prudential Rule Leverage Ratio										
6	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.25$, $\tau_m = 0.0$	1.8383	0.2798	0.6759	–412.2762	–52.6624	–2.9657	–0.0182	0.0090
7	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.50$, $\tau_m = 0.0$	1.8371	0.2801	0.6609	–412.3054	–52.6586	–2.9657	–0.0183	0.0091
8	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.75$, $\tau_m = 0.0$	1.8360	0.2803	0.6466	–412.3304	–52.6553	–2.9657	–0.0184	0.0091
9	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 1.00$, $\tau_m = 0.0$	1.8349	0.2805	0.6328	–412.3557	–52.6531	–2.9657	–0.0185	0.0092

Prudential Rule Loan-to-Value Ratio										
10	$\gamma_\pi = 1.5, \gamma_b = 0.0$	$\tau_v = 0.0, \tau_m = 0.25$	1.8673	0.2813	0.3882	–426.4613	–51.2596	–2.9873	–0.0723	0.0450
11	$\gamma_\pi = 1.5, \gamma_b = 0.0$	$\tau_v = 0.0, \tau_m = 0.50$	1.9010	0.2818	0.2653	–440.7115	–49.8495	–3.0091	–0.1237	0.0825
12	$\gamma_\pi = 1.5, \gamma_b = 0.0$	$\tau_v = 0.0, \tau_m = 0.75$	1.9374	0.2820	0.2015	–454.9620	–48.4394	–3.0308	–0.1723	0.1213
13	$\gamma_\pi = 1.5, \gamma_b = 0.0$	$\tau_v = 0.0, \tau_m = 1.00$	1.9757	0.2821	0.1625	–469.2112	–47.0295	–3.0526	–0.2181	0.1615

Table 3

Macroeconomic Volatility and Welfare after an Intangible Productivity Shock

	taylor	*prudential*	*vol out*	*vol infl*	*vol loan*	*wsav*	*wentr*	*wtot*	*wsavce*	*wentrece*
Standard Taylor Rule										
1	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8396	0.0362	0.0958	–407.7211	–55.1297	–3.0091	–1.2473e-04	–0.0514
Augmented Taylor Rule										
2	$\gamma_\pi = 1.5$, $\gamma_b = 0.25$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8397	0.0331	0.1097	–407.6824	–55.1342	–3.0091	3.0043e-05	–0.0515
3	$\gamma_\pi = 1.5$, $\gamma_b = 0.50$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8400	0.0308	0.1217	–407.6844	–55.1347	–3.0091	2.2220e-05	–0.0515
4	$\gamma_\pi = 1.5$, $\gamma_b = 0.75$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8403	0.0291	0.1316	–407.6859	–55.1352	–3.0091	1.6272e-05	–0.0515
5	$\gamma_\pi = 1.5$, $\gamma_b = 1.0$	$\tau_v = 0.0$, $\tau_m = 0.0$	1.8407	0.0280	0.1396	–407.6870	–55.1357	–3.0091	1.1657e-05	–0.0515
Prudential Rule Leverage Ratio										
6	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.25$, $\tau_m = 0.0$	1.8397	0.0362	0.0937	–407.7214	–55.1296	–3.0091	–1.2578e-04	–0.0514
7	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.5$, $\tau_m = 0.0$	1.8398	0.0362	0.0918	–407.7216	–55.1295	–3.0091	–1.2651e-04	–0.0514
8	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.75$, $\tau_m = 0.0$	1.8399	0.0362	0.0899	–407.7217	–55.1295	–3.0091	–1.2693e-04	–0.0514
9	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 1.00$, $\tau_m = 0.0$	1.8399	0.0362	0.0881	–407.7217	–55.1295	–3.0091	–1.2706e-04	–0.0514

Prudential Rule Loan-to-Value Ratio										
10	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 0.25$	1.8404	0.0363	0.0519	–407.8502	–55.1168	–3.0095	–0.0012	–0.0508
11	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 0.5$	1.8409	0.0363	0.0352	–407.9798	–55.1040	–3.0096	–1.5431e-04	–0.0069
12	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 0.75$	1.8412	0.0363	0.0266	–408.1095	–55.0911	–3.0097	–0.0017	–0.0505
13	$\gamma_\pi = 1.5$, $\gamma_b = 0.0$	$\tau_v = 0.0$, $\tau_m = 1.0$	1.8416	0.0363	0.0215	–408.2393	–55.0783	–3.0099	–0.0022	–0.0502