On the Effect of Monetary Stabilisation Policy on Long-run Growth

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Abstract

This paper presents a stochastic monetary growth model with nominal rigidities and active monetary policy in which technological change contains both deliberate (internal) and serendipitous (external) learning mechanisms. The model is used to describe how the implications of monetary stabilization policy for the long-run economic performance could change due to the ambiguity on the relationship between secular growth and cyclical volatility.

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1. Introduction

What do macroeconomic stabilisation policies imply for long-run growth? The answer to this question is not clear as the empirical findings on the relationship between long-run growth and short-run volatility are mixed.[1] Theoretically, the issue has been explicitly analysed in various stochastic endogenous growth models.[2] Martin and Rogers (1997), Blackburn (1999) and Blackburn and Pelloni (2005) are three recent

[1] See Kneller and Young (2001) for a survey on the empirical evidence.

[2] The nature of stochastic endogenous growth theory is that any shock could have a permanent effect on growth as long as it changes the amount on which technology growth depend (e.g., King et al. 1988; Stadler 1990; Bean 1990; Pelloni 1997; Fatas 2000).

contributions. The former shows that fiscal stabilisation policy has a positive effect on growth by considering a model of a real economy with perfect competition. By contrast, Blackburn (1999) finds a negative effect of monetary stabilisation policy on growth by considering a model of imperfect competition and nominal rigidities. Most recently, Blackburn and Pelloni (2005) considers a model of imperfect competition, nominal rigidities and multiple shocks in which monetary stabilisation policy has a positive effect on growth. In these analyses, serendipitous (external) learning is assumed to be an engine of endogenous technological change. As yet, however, there is no explicit analysis deals with the issue on the basis of the purposeful (internal) learning mechanism of technological change. The models based on this approach tend to predict a positive relationship between growth and volatility (e.g., Aghion and Saint-Paul, 1998a, 1998b).[3] Therefore stabilisation policy is expected to have a negative effect on growth.

This paper concerns the implications of monetary stabilisation policy in a simple a stochastic growth model, identical to Blackburn and Pelloni (2005), in which, however, both external and internal learning are integrated along the lines with Blackburn and Galindev (2003). As a result, *ex ante* uncertainty due to the variability of preference shocks has a negative effect on external learning, but a positive effect on external learning. Given the realisations of the shocks, this uncertainty has a negative (positive) effect on actual output growth if external (internal) learning is more important for technological change. Hence monetary policy eliminating this uncertainty has a promoting (deteriorating) effect on growth. In that respect, Blackburn

[3] See Canton (1996), Smith (1996), De Hek (1999), Jones et al. (1999) and Blackburn and Pelloni (2004) for contributions on the relationship between growth and volatility.

and Pelloni (2005) can be considered as a special case of the present analysis. However, it will be shown that the learning mechanisms are not sufficient to determine the relationship between growth and uncertainty (volatility) hence the implications of monetary stabilisation policy is not complete as output growth is a function of not only productivity growth but also changes in levels of employment between periods which are subject to the shocks. In general, the relationship between growth and volatility can be ambiguous depending on the parameter values.

The remainder of this paper is organised as follows. In Section 2, I set up the model. In Section 3, I solve for the stochastic dynamic general equilibrium. In Section 4, I establish the main results. And in Section 5, I conclude the analysis.

2. Model

I consider an artificial economy consisting of constant populations (normalised to one) of identical, infinitely lived households and identical, competitive firms. I use Blackburn and Pelloni (2005)'s model and that is also used by Blackburn and Galindev (2003). In particular, I assume logarithmic utility functions, Cobb-Douglas production functions and no accumulation of capital to simplify the computations and admit closed-form solutions.

2.1 Firms

The representative firm produces Y_t units of output by hiring N_t units of labour in accordance with the following Cobb-Douglas technology,

$$Y_t = \Psi Z_t N_t^{\alpha}, \qquad \Psi > 0, \qquad \alpha \in (0,1) \tag{1}$$

$$Z_t = Z_{t-1}\Omega s_{t-1}^{\varphi}\bar{N}_{t-1}^{\vartheta}, \qquad \Omega > 1, \qquad \varphi, \vartheta > 0. \tag{2}$$

The term Z_t is a technology shift factor in the production function and it evolves according to (2) which contains both purposeful (internal) and serendipitous (external) learning behaviours as in Blackburn and Galindev (2003). The former is represented by s_{t-1} which employees spend intentionally to improving their productivity efficiency. The latter is captured by $\bar{N}_t$, the aggregate level of employment which determines the index of knowledge which each employee takes rationally as given. The relative importance of these two learning behaviours for productivity growth is measured by the relative magnitudes of the parameters φ and ϑ. Extreme cases are obtained by setting $\{\varphi = 0, \vartheta > 0\}$ for purely external learning and $\{\varphi > 0, \vartheta = 0\}$ for purely internal learning.[4]

Firms hire labour from households at the real wage rate $\frac{W_t}{P_t}$ where W_t denotes the nominal wage and P_t denotes the price of output. Profit maximisation implies

$$\frac{W_t}{P_t} = \alpha\Psi Z_t N_t^{\alpha-1} = \frac{\alpha Y_t}{N_t}. \tag{3}$$

2.2 Households

The discounted lifetime utility function of the representative household is

$$U = \sum_{t=0}^{\infty}\beta^t\left[v_t\Upsilon\log(C_t) + \theta\log\left(\frac{M_{t-1}\phi_t}{P_t}\right) + \lambda\log(1 - s_t - L_t)\right], \tag{4}$$

$$\beta \in (0,1); \;\; \Upsilon, \theta, \lambda > 0,$$

[4] Although there is no capital in the present model, the case of $\{\varphi = 0, \vartheta > 0\}$ can be considered as a reflection of the economy in Blackburn and Pelloni (2005).

where C_t denotes consumption, $\frac{M_{t-1}\phi_t}{P_t}$ denotes real money balances, L_t denotes time spent to working and s_t denotes time spent to improving productivity efficiency (e.g., through formal education, research and training) which is a deliberate (internal) learning activity. The quantity M_{t-1} denotes nominal cash balances at the beginning of period t which are augmented by a proportional monetary transfer, ϕ_t. This transfer will be discussed in the next section. Fluctuations in the economy are the result of preference (or taste) shocks, as captured by the utility weight on consumption, v_t, similar to several other models (e.g., Ireland, 1997, 2000; Blackburn and Galindev, 2003).[5] In this model, this shock is assumed to be an identically and independently distributed random variable with a unit mean and a constant variance σ_v^2.

The budget constraint of the representative household is given by

$$C_t + \frac{M_t}{P_t} = \frac{W_t}{P_t} L_t + \frac{M_{t-1}\phi_t}{P_t} + \pi_t \tag{5}$$

where π_t denotes dividends. The representative household maximises the utility function in (4) subject to the series of budget constraints in (5) by choosing optimal paths for C_t, M_t, L_t and s_t. The first order condition with respect to money balances is as follows:

$$\frac{v_t}{C_t P_t} = \frac{\beta\theta}{\Upsilon M_t} + \beta E_t\left(\frac{v_{t+1}\phi_{t+1}}{C_{t+1}P_{t+1}}\right). \tag{6}$$

The first order condition with respect to L_t depends on the assumption about the labour market. I follow Blackburn and Pelloni (2004, 2005) in which households are

[5] Blackburn and Pelloni (2005) considers λ as a random shock alongside money supply and productivity shocks.

assumed to have a monopoly power and choose a nominal wage at which households supply whatever labour is demanded by firms. In addition, it is assumed that wages are set for one period in advance, before the realisation of the demand shock. Thus the economy displays nominal rigidities.[6] Under such circumstances, the representative household internalises the response of labour demand in (3) in the utility maximisation process to find the optimal wage at the end of period $t-1$ for period t.[7] Accordingly, the optimal time spent to working must satisfy the following condition:

$$E_{t-1}\left(\frac{L_t}{1-s_t-L_t}\right)=\frac{\alpha\Upsilon}{\lambda}W_t E_{t-1}\left(\frac{v_t L_t}{C_t P_t}\right). \qquad (7)$$

The optimal time spent to improving productivity efficiency, s_t, must satisfy the following condition:

$$\frac{s_t}{1-s_t-L_t}=\frac{\alpha\varphi\beta\Upsilon}{\lambda}E_t\left(\frac{v_{t+1}Y_{t+1}}{C_{t+1}}\right). \qquad (8)$$

2.3 Monetary Policy Rule

The total supply of money in the economy is given by

$$H_t=\phi_t H_{t-1} \qquad (9)$$

where H_t denotes the nominal money supply at period t. As in Gali (1999), Ireland (1997) and Blackburn and Pelloni (2005), monetary policy is assumed to be governed by a feedback rule by which the central bank responds to the demand shock. This feedback rule determines the growth rate of the money supply as

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[6] See, Blackburn and Pelloni (2005) for more discussions.

[7] In other words, the labour demand, $N_t=\left(W_t/P_t\right)^{1/(\alpha-1)}\left(1/\alpha\Psi Z_t\right)^{1/(\alpha-1)}$, is used for L_t in the maximisation.

$$\phi_t = g v_t^{\rho}, \qquad g > 0 \tag{10}$$

where g is the deterministic and exogenous part of the money growth rate and ρ is a feedback parameter, the magnitude of which shows the degree of response of monetary policy to the demand shock, v_t in (4). When $\rho = 0$, monetary policy is completely unresponsive to changes in the state of the economy and the money supply grows at the exogenous constant rate, g. By contrast, when $\rho \neq 0$, monetary policy responds to the demand disturbances so that monetary growth is stochastic.

3. General Equilibrium

The general equilibrium of this model is computed by combining all the relationships obtained so far with the market clearing conditions, $C_t = Y_t$ (for goods), $H_t = M_t$ (for money), and $N_t = L_t$ (for labour).

Substituting the money market equilibrium condition together with the transversality condition, $Lim_{\tau\to\infty}\beta^{\tau}E_t\left(\frac{v_{t+\tau}M_{t+\tau}}{C_{t+\tau}P_{t+\tau}}\right) = 0$, into (6) yields

$$\frac{M_t}{P_t} = \frac{b}{v_t}Y_t, \tag{11}$$

where $b = \beta\theta / \Upsilon(1-\beta)$. According to (11), the equilibrium real money balances is a stochastic proportion of the level of output. An increase in the demand shock, v_t, leads to lower real money balances and vice versa.

Using (3) and (11), one could write the equilibrium time spent to working as follows:

$$N_t = \frac{\alpha v_t M_t}{b W_t}. \tag{12}$$

Substituting the money supply process in (9) and (10) into (12) yields

$$N_t = \frac{\Theta v_t^{1+\rho}}{W_t} \tag{13}$$

where $\Theta = \alpha g H_{t-1} / b$. Using (8) and (13), I write the equilibrium time spent to improving technology as follows:

$$s_t = \Phi \left(1 - \frac{\Theta v_t^{1+\rho}}{W_t} \right) \tag{14}$$

where $\Phi = \alpha\beta\varphi\Upsilon / (\lambda + \alpha\beta\varphi\Upsilon)$. According to (13) and (14), the realisation of the demand shock, v_t, could cause stochastic fluctuations in the economy through the equilibrium time spent to working and improving technology if $\rho \neq -1$. Monetary policy can indeed stabilise the fluctuations by setting $-1 \leq \rho < 0$. Moreover, setting $\rho = -1$ eliminates the effect of the demand shock from (13) and (14) completely. Now examine how the expectation of the shock, $E_{t-1}(v_t)$, affects N_t and s_t through the nominal wage, W_t, which is set in period $t-1$. Notice in (13) and (14) that nominal wages are negatively related with time spent to working, but positively related with time spent to improving technology.

After some manipulations, I combine (7) and (8) into the following expression:

$$E_{t-1}\left(\frac{N_t}{1 - N_t} \right) = \Pi \tag{15}$$

where $\Pi = \alpha^2 \Upsilon / (\lambda + \beta\varphi\alpha\Upsilon)$. Substituting (13) into (15) yields

$$E_{t-1}\left(\frac{\Theta v_t^{1+\rho}}{W_t - \Theta v_t^{1+\rho}} \right) = \Pi . \tag{16}$$

If the monetary policy is fully responsive to the fluctuations – i.e., $\rho = -1$, households set the following constant nominal wage in every period.

$$\hat{W} = \frac{\Theta(1+\Pi)}{\Pi} \tag{17}$$

Under such circumstances, the environment can be treated as non-stochastic. If monetary policy partially or never responds to the shock – i.e., $-1 < \rho \leq 0$, whether the nominal wage is to be set higher or lower than that in (17) depends on the functional properties of the expression inside the expectations operator in (16) with respect to the shock, v_t. Rewrite (16) as $E_{t-1}\left(F\right) = \Pi$ where $F = \frac{\Theta v_t^{1+\rho}}{W_t - \Theta v_t^{1+\rho}} = f(v_t, W_t)$. It is found to be not possible to determine the sign of $f_{11}(\cdot)$ for $-1 < \rho < 0$ as it depends on v_t which is unknown in period $t-1$. Thus I will concentrate on the case where $\rho = 0$, implying that monetary policy is completely unresponsive to the shocks. Under such circumstances, the function $f(\cdot)$ is an increasing and convex function of the demand shock v_t ($f_1(\cdot) > 0$, $f_{11}(\cdot) > 0$) and a decreasing function of the nominal wage W_t ($f_2(\cdot) < 0$). Since Π is constant and $f(\cdot)$ goes through $Mean(v_t)$ (which equals $v_t^{1+\rho}$ when $\rho = -1$), $\sigma_v^2 > 0$ implies that $E_{t-1}(F)$ exceeds Π hence the nominal wage, W_t, must exceed $\hat{W}$. In order words, the nominal wage in the purely stochastic environment is always higher than that in the non-stochastic one. Thus an increase in uncertainty (an increase in σ_v^2) leads to a decrease in time spent to working, but an increase in time spent in improving productivity by increasing W_t.[8]

[8] Blackburn and Pelloni (2005) obtains the same result on the relationship between uncertainty and time spent to working explicitly as internal learning is not considered in their analysis.

4. Growth, Volatility and Stabilisation Policy

In this section, I examine the implications of monetary stabilisation policy for long-run growth. In equilibrium, $N_t = \bar{N}_t$. Substituting (13) and (14) into (2) and (1) yields the following expression for the growth rate of output between two consecutive periods:

$$\frac{Y_{t+1}}{Y_t} = \Omega\Phi^{\varphi}\left(1 - \frac{\Theta v_t^{1+\rho}}{W_t}\right)^{\varphi}\left(\frac{\Theta v_t^{1+\rho}}{W_t}\right)^{\vartheta}\left(\frac{v_{t+1}}{v_t}\right)^{(1+\rho)\alpha}. \tag{18}$$

Fully responsive monetary policy creating a non-stochastic environment – i.e., $\rho = -1$ implies a constant output growth, that is

$$\frac{Y_{t+1}}{Y_t} = \Omega\Phi^{\varphi}\left(1 - \frac{\Theta}{\hat{W}}\right)^{\varphi}\left(\frac{\Theta}{\hat{W}}\right)^{\vartheta} \equiv \hat{y} \tag{19}$$

By contrast, if monetary policy is completely unresponsive – i.e., $\rho = 0$, the expected growth rate of output turns out to be purely stochastic.[9]

$$\frac{Y_{t+1}}{Y_t} = \Omega\Phi^{\varphi}\left(1 - \frac{\Theta v_t}{W_t}\right)^{\varphi}\left(\frac{\Theta v_t}{W_t}\right)^{\vartheta}\left(\frac{v_{t+1}}{v_t}\right)^{\alpha} \equiv y(W_t, v_t, v_{t+1}) \tag{20}$$

According to (20), whether this output growth in expectation is greater or less than that in (19) hence the implication of the fully responsive monetary stabilisation policy depends on the functional properties of $y(\cdot)$ with respect to W_t, v_t and v_{t+1}. Cyclical uncertainty (or volatility) due to $\sigma_v^2 > 0$ has an effect on the average growth, $E_t(y_{t+1})$, through W_t (indirect effect) but also through the non-linearities of $y(\cdot)$ with respect to v_t and v_{t+1} (direct effect). I approximate output growth in (20) around $v_t = v_{t+1} = Mean(v_t) = 1$ and $W_t = \hat{W}$ and then take expectations. As a result, I find

[9] I concentrate only on the fully responsive monetary policy is as it is shown before that it is not possible to determine the response of W_t to uncertainty when $-1 < \rho < 0$.

$$E_t(y_{t+1}) \approx y(\hat{W},1) + y_1(\hat{W},1)w_t + \frac{1}{2}\Big(y_{22}(\hat{W},1) + y_{33}(\hat{W},1)\Big)\sigma_v^2 \qquad (21)$$

where $w_t = (W_t - \hat{W}) > 0$. Since $y(\hat{W},1)$ is equal to non-stochastic output growth in (19) – i.e., $y(\hat{W},1) = \hat{y}$, whether $E_t(y_{t+1}) \gtreqless \hat{y}$ depends on the sign of $f(\varphi,\vartheta) \equiv y_1(\hat{W},1)w_t + \frac{1}{2}\Big(y_{22}(\hat{W},1) + y_{33}(\hat{W},1)\Big)\sigma_v^2$ which reflects the functional properties of $y(\cdot)$. The direct effect of σ_v^2 is reflected in the term, $(y_{22}(\hat{W},1) + y_{33}(\hat{W},1))$, whereas the indirect effect through w_t is captured by the term, $y_1(\hat{W},1)$. After substituting the appropriate derivatives, the following expression is found

$$f(\varphi,\vartheta) = y(\hat{W},1)\left[\left(\frac{\varphi\Theta - \vartheta(\hat{W}-\Theta)}{(\hat{W}-\Theta)\hat{W}}\right)w_t + \right. \\ \left. + \frac{1}{2}\left(\frac{\varphi(\varphi-1)\Theta^2}{(\hat{W}-\Theta)^2} - \frac{2\varphi(\vartheta-\alpha)\Theta}{\hat{W}-\Theta} + (\vartheta-\alpha-1)(\vartheta-\alpha) + \alpha(\alpha-1)\right)\sigma_v^2\right]. \qquad (22)$$

Other things being equal, the effect of *ex ante* uncertainty through w_t on $f(\cdot)$ depends on the magnitudes of the parameters measuring the relative importance of both types of learning for productivity growth, φ and ϑ. Let us first consider each of two extreme cases in turn. If the mechanism entails only external learning – i.e., $\{\varphi = 0, \vartheta > 0\}$, an increase in uncertainty through an increase in w_t leads $f(0,\theta)$ to decrease. This is the result reached by Blackburn and Pelloni (2005), implying that stabilising fluctuations or decreasing uncertainty could promote output growth. Conversely, if the underlying mechanism of technological change is based solely on internal learning – i.e., $\{\varphi > 0, \vartheta = 0\}$, an increase in w_t due to increasing uncertainty leads $f(\varphi,0)$ to increase. Under such circumstances, fully responsive monetary policy could deteriorate growth. If both types of learning matter – i.e., $\{\varphi > 0, \vartheta > 0\}$, *ex ante* uncertainty has a positive effect on $f(\cdot)$ through w_t if $\varphi\Theta > \vartheta(\hat{W} - \Theta)$ – i.e., technological change is determined predominantly by internal learning and vice versa.

Since output growth is also directly affected by the realisations of the shocks, the effect of *ex ante* uncertainty on technological change through w_t may not be sufficient to justify the implications of monetary stabilisation policy for output growth. Under such general circumstances, one could impose some additional conditions to retreat the results in the extreme cases. For example, $\vartheta > \alpha$ is a sufficient condition for $f(0,\theta) < 0$ in the case of $\{\varphi = 0, \vartheta > 0\}$ whilst ($\varphi \geq 1$) is sufficient for $f(\varphi, 0) > 0$ when $\{\varphi > 0, \vartheta = 0\}$. In general, whether $f(\varphi, \vartheta) \gtreqless 0$ depends on the parameter values in the model. As can be seen, $f(\cdot)$ has $\cup$-shaped relationships with both φ and ϑ. Instead of solving for the roots, suppose that there exists a set of values for these parameters, $\{\varphi^*, \vartheta^*\}$, such that $f(\varphi^*, \vartheta^*) = 0$. Differentiating $f(\cdot)$ with respect to $\varphi > \varphi^*$ and $\vartheta > \vartheta^*$ individually around $\{\varphi^*, \vartheta^*\}$ yields the following general results:

$$f(\varphi, \vartheta^*) \gtreqless 0 \text{ for } \varphi > \varphi^* \text{ if } \frac{\Theta w_t}{(\hat{W} - \Theta)\hat{W}} + \frac{\Theta^2 (2\varphi^* - 1)\sigma_v^2}{2(\hat{W} - \Theta)^2} \gtreqless \frac{\Theta(\vartheta^* - \alpha)\sigma_v^2}{(\hat{W} - \Theta)}, \tag{23}$$

$$f(\varphi^*, \vartheta) \gtreqless 0 \text{ for } \vartheta > \vartheta^* \text{ if } \left(\vartheta^* \sigma_v^2 - \frac{w_t}{\hat{W}}\right) \gtreqless \left(\frac{2\varphi^* \Theta}{(\hat{W} - \Theta)} + 2\alpha + 1\right)\frac{\sigma_v^2}{2}. \tag{24}$$

The expressions in (23) and (24) show the possibilities that the predicted relationship between growth and volatility through learning mechanisms can be reversed when the effect of *ex ante* uncertainty is dominated by the direct (non-linear) effect of the shock.

5. Conclusions

The objective of this paper has been to extend the existing literature on the implications of macroeconomic stabilisation policy for long-run growth. I have considered a stochastic monetary growth model, similar to Blackburn and Pelloni (2005) with nominal rigidities and active monetary policy, but with both internal and external learning mechanisms as in Blackburn and Galindev (2003). It has been shown that monetary policy leading to a non-stochastic environment by eliminating the stochastic fluctuations arising from the demand shocks could promote (deteriorate) growth if the underlying relationship between growth and volatility is negative (positive). I have shown that learning mechanisms are not sufficient to determine the sign of this relationship due to a non-linear relation of the shocks with output growth. In other words, even if one learning is more important for technological growth than another, an ambiguity could exist on the relationship between growth and volatility. The extreme cases of the model tend to be consistent with the existing contributions subject to additional conditions. Specifically, the analysis based on purely external (internal) leads to a negative (positive) relationship between growth and volatility, implying that stabilisation policy has positive (negative) effect on growth. In that respect, Blackburn and Pelloni (2005) can be considered as a special case of the model. In general, a set of parameter values are determined to clarify the overall relationship between growth and volatility.

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