Banking and Interest Rates in Monetary Policy Analysis: A Quantitative Exploration

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This paper embeds a fully-specified banking sector into a dynamic stochastic general equilibrium framework. The goal of the paper is to provide a first attempt at quantifying the effects of banking in general equilibrium, in terms of both its steady-state implications and dynamic properties. The paper provides valuable insights into the valuation of liquidity services provided by various financial instruments through its steady-state analysis and a rich exploration of dynamic model properties and policy-relevant questions through simulation exercises conducted under alternative monetary policy scenarios.

In principle a general equilibrium model augmented to include a fully micro-founded banking sector can provide a nice contrast to the current generation of dynamic New Keynesian (DNK) models which imply that monetary aggregates are not important for policy or welfare analysis. Although most DNK models ignore monetary aggregates, recently, policy institutions such as the BIS and the Bank of England have expressed concern about rapid growth of such aggregates. In addition, understanding the role of the banking sector may help explain historical episodes such as the Great Depression as well as the financial crises that swept through Asia and Scandinavia during the late 1980s and 1990s. These crises are often linked to developments in the banking sector. More generally, the bank-lending channel may be an important component of the monetary transmission mechanism. It is therefore important to develop fully fleshed-out models that include banking in general equilibrium, and I enthusiastically welcome these efforts.

The model in this paper has a number of key ingredients. It specifies a transactions demand for money combined with loanable funds that are created through the banking system. The key component of the model is a lending production function that combines banking effort with collateral. The driving assumption here is that bank effort serves as a substitute for collateral for agents seeking to obtain loans. Increased banking effort is obtained through an increase in employment in the banking sector.

The main contributions of the model are threefold: 1) It provides a methodology to value liquidity services provided by various assets based on their ability to serve as collateral for loans. In this regard, the calibrated model does a good job of characterizing steady-state interest rate differentials given key assumptions regarding the loan production function and the degree of substitutability between collateral and effort. 2) Model dynamics suggest that the model may either amplify or dampen the effect of exogenous shocks owing to movements in the external finance premium. There are two forces at work here. A positive shock raises collateral values and increases loan supply. Such a shock also increases deposit demand and hence the amount of banking...
services that are provided in general equilibrium. By increasing banking services, the latter attenuates the former. 3) It provides counter-factual analyses that highlight the importance of understanding the determinants of liquidity services when conducting monetary policy.

**Steady-state properties:**

The model’s steady state implies a set of interest rates that determine the liquidity service yield on different types of financial instruments. For an uncollateralized loan, the liquidity service yield is

\[ R^T - R^B = \left[ \frac{MU(C)}{\lambda} - 1 \right] \Omega \]

where

\[ \Omega = \frac{\alpha c}{b + kqK} \]

measures the marginal value of collateral and \( MU(C)/\lambda \) measures household marginal utility relative to the households shadow value of funds. The value of collateral thus depends on the fraction of loans that are backed by government bonds versus capital. For a collateralized loan, the liquidity service yield is defined as

\[ R^L - R^B = \left[ \frac{MU(C)}{\lambda} - 1 \right] \kappa \Omega \]

where \( \kappa \) determines the extent to which capital is collateralizable. These two equations imply that liquidity services are high when either the value of collateral is high, or when marginal utility is high relative to the household value of internal funds.

The model also defines the uncollateralized external finance premia as the difference in interest rates on uncollateralized loans relative to the inter-bank interest rate \( R^T - R^{IB} \), and the collateralized external finance premium, \( R^L - R^{IB} \), as the difference between the collateralized loan rate and the inter-bank interest rate. The model implies that the uncollateralized external finance premium is proportional to the collateralized external finance premium which depends on

\[ \left[ \frac{MU(C)}{\lambda} - 1 \right]. \]

In this model, the marginal value of collateral, \( \Omega \), plays no role in determining either the spread (in percentage terms) on collateralized versus non-collateralized loans, \( (R^T/R^L) \), or the external finance premia. These strikes me as special results however, driven by functional form assumptions. More generally, one would expect both the percentage spread between non-collateralized loans and collateralized loans and the external finance premia to depend explicitly on the value of collateral.

The model focusses on frictions for loans to finance consumption goods rather than investment goods. This assumption has obvious implications for how the model will behave, and these assumptions drive some of the key results for both steady-state and
dynamic analysis. In particular, the fact that capital falls as the efficiency of banking improves is a direct consequence of the assumption that household consumption is tied one-for-one with lending behavior. Because capital provides collateral services, households over-invest in capital when the banking sector is inefficient. This “excess capital effect” would be undone to the extent that entrepreneurs need to finance investment goods through collateralized lending however.

The steady-state calibration also implies a very low level of the collateralized value of capital determined by the parameter $\kappa$. This low value is required to match the high return on equity. Thus, the model seems to be able to provide a high equity premium at the cost of assuming that, although the value of capital in production is high, its value as collateral is very low.

**Model Dynamics:**

To understand model dynamics, it is useful to consider a simplified version of the model that has an infinite labor supply elasticity. In this case, one can show that the log-linearized system is determined by the following set of equations.

**The Banking Sector:**

The supply of banking services is determined by the loan production function

$$c_t = (1 - \alpha)m_t + \alpha \left[ \frac{b}{b + k} (b_t + c_t) + \frac{k}{b + k} q_t \right]$$

where $1 - \alpha$ denotes the share of banking sector services in loan production. The demand for banking services is determined by the wedge between the marginal utility of consumption and the shadow value of household funds:

$$m_t = \left( \frac{c(1 - \alpha)}{mw} \right) \left[ (-c_t) - \lambda_t \right].$$

Based on the calibrated values, we have that

$$\frac{c(1 - \alpha)}{mw} \approx 25.$$

Thus banking sector employment is highly responsive to the collateralized external finance premium $(c_t + \lambda_t)$.

**Aggregate supply:**

The aggregate supply block is a standard New Keynesian formulation. With constant capital, production satisfies

$$c_t = (1 - \eta)(n_t + a_t)$$

and marginal cost may be computed as

$$mc_t = n_t + w_t - c_t$$
Infinite labor supply elasticity implies that the labor supply curve is flat so that

\[ w_t = -\lambda_t. \]

Finally, the Calvo pricing assumption implies the New Keynesian Phillips curve:

\[ \pi_t = \kappa mc_t + \beta E_t \pi_{t+1} + u_t. \]

**Aggregate Demand:**

In principle, models with financial frictions based on collateral lending have the potential to have an important asset price mechanism working through the aggregate demand channel. An increase in economic activity causes a rise in asset prices and an increase in the value of collateral. The rise in collateral values leads to more borrowing and more economic activity. The extent to which such a mechanism amplifies shocks depends on the extent to which collateralized lending influences aggregate demand.

The aggregate demand side of the model is determined by the marginal value of collateralized lending:

\[ \Omega_t = \frac{k}{b+k}c_t - \left[ \frac{k}{b+k}q_t + \frac{b}{b+k}b_t \right] \]

combined with the equilibrium asset pricing condition:

\[ q_t = E_t \lambda_{t+1} - \lambda_t + \frac{r}{1+r}E_t mpk_{t+1} + \frac{1}{1+r}E_t q_{t+1} + \left( k_\Omega \left( \frac{\phi}{c_\lambda} - 1 \right) \right) (\Omega_t + q_t) + \frac{k_\Omega}{c_\lambda} ((-c_t) - \lambda_t). \]

The expression for \( \Omega_t \) implies that the marginal value of collateralized lending is high when the value of collateral (the expression in brackets) is low relative to consumption. The asset pricing equation implies that, in principle, fluctuations in the marginal value of collateralized lending can lead to increased volatility of asset prices, and positive feedback effects. The strength of this mechanism depends on the elasticity \( k_\Omega \left( \frac{\phi}{c_\lambda} - 1 \right) \).

To understand the role that asset prices may play in generating interesting dynamics, one must consider the calibrated version of the model. The model’s calibration implies:

\[ \frac{k_\Omega}{c_\lambda} \approx 0.049 \]

and

\[ k_\Omega \left( \frac{\phi}{c_\lambda} - 1 \right) \approx 0.002. \]

Because this elasticity is so low, there is almost no endogenous feedback through asset prices in this model, and since \( \Omega_t \) only appears in the asset pricing equation, the value of collateral plays virtually no role in determining aggregate demand and therefore no role in determining the model’s dynamic properties.
Finally, the model is closed by specifying a monetary policy rule:

$$\Delta h_t = \rho \Delta h_{t-1} + \varepsilon_t$$

combined with a cash in advance constraint.

$$\Delta c_t = \Delta h_t - \pi_t.$$ 

The cash in advance constraint imposes the constant velocity assumption.

Given this simplified version of the model, it is interesting to consider what are the key ingredients that determine the model’s dynamic properties. I am particularly interested in understanding the role that banking services and collateral values can play in generating interesting dynamics. To do so, I consider the impulse response of this simplified model to a shock to the money growth rate. I first assume that the persistence of money growth is 0.6, and plot the impulse response of consumption and inflation to a 1% money growth shock. These results are displayed in Figure 1 and Figure 2. I then consider the case where the autocorrelation of money growth is 0.95. Here I only plot consumption growth which is displayed in Figure 3.

In addition to simulating the actual model described above, I consider what happens when there is no variation in the marginal value of collateralized lending ($\Omega_t = 0$) and what happens when there is no variation in banking services ($m_t = 0$). I also plot the impulse response of the model that does not have any banking-sector frictions – this model sets both $\Omega_t = 0$ and $m_t = 0$, and corresponds to the standard dynamic New Keynesian model without capital and a money-growth rule for policy.

According to the results displayed in Figure 1 and Figure 2, the impulse response to money growth has a pronounced effect on both consumption and inflation. Consistent with the intuition provided above, model dynamics are virtually the same whether or not one allows for variation in the marginal value of collateralized lending through its effect on asset prices. Model dynamics are clearly influenced by the banking sector however. With $m_t$ held constant, consumption and inflation dynamics are severely muted relative to the case where $m_t$ is allowed to respond endogenously. When $m_t$ is allowed to respond, the consumption and inflation path for the model with the banking sector essentially replicates the consumption and inflation path for the standard New Keynesian model without banking frictions however. As can be seen in Figure 3, one obtains similar implications for the case where the autocorrelation of the monetary growth rate is 0.95.

These simulation results may be summarized as: 1) the model as it is currently calibrated does not contain a quantitatively interesting asset-price mechanism that links movements in collateral to consumption; 2) model dynamics are highly sensitive to the response of the banking sector; and 3) with a Cobb-Douglas production function for banking services, the banking sector is sufficiently responsive as to be able to replicate the consumption and inflation dynamics implied by the model without banking frictions.
These last two findings suggest that the production function of the banking sector is a key component that determines model dynamics. While Cobb-Douglas is an appealing choice, I suspect that the elasticity of substitution between collateral and bank effort is in fact much lower. The model with a low elasticity of substitution between collateral and bank effort would behave more like the fixed $m_t$ case. It would thus be of substantial interest to explore the role that the form of the production function plays in determining model properties. It would also be of substantial interest to have empirical evidence that would provide information on the correct elasticity of substitution.

A caveat here is that I have assumed an infinite labor supply elasticity. With the infinite labor supply elasticity, model dynamics are driven by the wedge $\mu(c)/\lambda$ combined with how responsive the banking sector is to that wedge. While moving away from infinite labor supply elasticity may alter some model properties, I am not sure it would undo these basic findings to any significant degree.

The authors make a very nice point that the banking sector can serve as an endogenous attenuation mechanism to what might otherwise be a strong amplification device generated by cyclical movements in the external finance premium. The extent to which the banking sector can do so depends however on how asset values respond to economic fluctuations, and the role that asset values have in determining collateral services. Because all loans are for consumption rather than investment, I suspect the attenuation effect is much stronger than one would observe in a model with collateralized lending to both households and firms. In addition, as noted above, the key parameter determining collateral values, $\kappa$, is calibrated to be a small number – given this calibration, it would seem that fluctuations in asset prices necessarily have a only a small impact on collateral services.

Finally, given the specified intent to embed banking in general equilibrium, one is naturally left to wonder what role monetary aggregates may play in the analysis. A major motivation for studying the banking sector is presumably to understand the extent to which monetary aggregates have independent effects or contain information that is independent of nominal interest rates. The current paper emphasizes the potential hazards from focussing on the “wrong” interest rate, i.e. by mistaking movements in the lending rate for movements in the inter-bank rate. In the current formulation of the model however, given a nominal interest rate rule, monetary aggregates play no role in determining model dynamics. Thus, a policy maker can safely ignore the evolution of such aggregates when setting monetary policy. This finding stems directly from the constant velocity assumption however. Thus relaxing this assumption would enrich the specification of the banking sector and provide further insight into the role that monetary aggregates should play in determining the conduct of monetary policy.

In summary, this paper provides an interesting model of a banking sector linked to household consumption. The paper shows that calibration to long-run values has important implications for the size of liquidity services, and interest rate differentials.
Future work needs to relax the constant velocity assumptions to obtain a model where monetary aggregates provide independent information however. One would also need to modify assumptions regarding the role of collateral to obtain amplification and propagation through the financial sector. I suspect a key step in this process is to enrich the model by allowing for collateralized lending for investment as well as consumption goods. Overall, this paper provides an insightful first step towards a fully integrated model of the banking sector that is a necessary ingredient to understand a variety of policy issues of concern today. I look forward to future research on this topic.
Figure 1: Consumption ($\rho = 0.6$)
Figure 2: Inflation ($\rho = 0.6$)
Figure 3: Consumption ($\rho = 0.95$)