ESSAYS ON UNCONVENTIONAL MONETARY POLICY

by

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A DISSERTATION

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ABSTRACT

This dissertation is comprised of three essays in which I provide a theoretical framework to study the transmission mechanism of unconventional monetary policy on real activity and credit markets under differing degrees of banking sector concentration. In particular, the three chapters in this dissertation focus on expansionary balance sheet policies consisting of long-term asset purchases by a central bank. The overall results indicate that such expansionary policies stimulate economic activity in the form of capital formation, increased credit volume and financial easing under low short-term interest rate economies when the financial sector is perfectly competitive. However, when the banking sector is fully concentrated, the transmission mechanism of monetary policy can be distorted and thus the impact of a long-term security purchase program is hampered. Our results also suggest that the fiscal authority as well as the industrial organization of the banking sector play fundamental roles in the transmission mechanism of unconventional monetary policy.

DEDICATION

To my sisters Socorro, Gloria and Patricia for the affection that only great sisters are able to show. To my beloved parents, Socorro and Gabino whose unconditional love and support have always been my main source of inspiration during the harshest of times.

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CHAPTER 1
INTRODUCTION

The 2007-2009 financial recession forced central banks around the world to the use of nontraditional policy tools in order to stimulate economic activity. A distinctive example was a historically unprecedented expansion of the size of their balance sheets through the purchase of long-term government securities.

This dissertation is comprised of three essays in which I provide a theoretical framework to analyze the effects of unconventional monetary policy on real activity and credit markets under differing degrees of banking sector concentration. Namely, the essays herein focus on expansionary balance sheet policies consisting of long-term asset purchases by a central bank. The overall results indicate that such expansionary policies stimulate economic activity in the form of capital formation, increased credit volume and financial easing under low short-term interest rate economies when the financial sector is perfectly competitive. However, when the banking sector is fully concentrated, the transmission mechanism of monetary policy can be distorted.

In the first chapter, I construct a rigorous modeling framework to investigate the impact of such policies. The inclusion of long term assets and an independent central bank allows us to focus on a Treasury bond purchase program as a monetary policy tool. Outright open market operations through purchases of short-term government securities unambiguously lower yields and promote economic activity. By comparison, long-term asset purchases are only effective if short-term yields are sufficiently low. Should central bankers in countries with high debt loads and high short-term interest rates implement a long-term asset purchase program, it will be ineffective as it would only encourage fiscal authorities to issue more debt. Moreover, I also explain how the transmission channels of monetary policy between unconventional and conventional policies have important consequences for risk sharing in the economy.

In the second chapter, I now focus on the implications of unconventional monetary policy for credit market activity. Namely,I analyze the effect on credit markets of this unconventional monetary policy tool and compare it with that of conventional instruments such as purchases of short-term government debt. Our framework takes into account the role of financial intermediaries that provide risk sharing and intertemporal consumption-smoothing services in the transmission mechanism of monetary policy. Our findings suggest that central bank purchases of long-term government securities stimulate credit market activity and reduce the cost of public and private borrowing only under a low interest rate and reduced fiscal debt regime. Otherwise, this policy increases the cost of servicing debt resulting in a contraction of lending. In contrast, short-term government debt purchases aid credit availability but negatively affect the amount of risk sharing in the economy.

Finally, in the third chapter, I analyze the implications of competition in the banking sector for the ability of expansionary balance sheet policies to affect credit market activity. Under this objective I also explore conventional instruments such as a rate of money growth. In particular, I analyze this issue in a framework in which banks simultaneously offer risk sharing and intertemporal consumption-smoothing services in the presence of government debt. Our results suggest that under perfectly competitive banks, increased rates of money growth reduce interest rates and increase loan volume. This also holds in high debt economies if the crowding out effect of government debt is low. Similarly, central bank bond purchases unambiguously promote credit market activity. In contrast, under a monopoly bank, higher rates of money growth reduce funding costs and promote lending except when interest rates are low and liquidity shocks are of considerable magnitude.

CHAPTER 2
THE SIZE OF THE CENTRAL BANK'S BALANCE SHEET: IMPLICATIONS FOR CAPITAL FORMATION AND THE YIELD CURVE

2.1 Introduction

In recent years, central banks around the world resorted to balance sheet expansion policies that reached unprecedented levels in order to promote economic activity. In the United States, for example, the Federal Reserve increased the size of its balance sheet more than fourfold: total assets increased from 0.92 trillion dollars in August 2008 to 4.3 trillion dollars in May 2014.[1] The impact of balance sheet policies in the U.S. had important effects on longer-term interest rates. Notably, a number of studies point out that the cumulative effects of quantitative easing as well as Operation Twist led to a reduction between 80 and 120 basis points on the yield of 10 year Treasury-securities.[2] In a similar manner, Bauer and Neely (2014) argue that the purchases also affected international bond yields. In addition, other major central banks such as the Bank of England have also pursued extensive balance sheet policies around the same time as the Federal Reserve.

Moreover, aside from recent years, the possibility of such interventions was raised earlier by Bernanke (2003) and Bernanke and Reinhart (2004). They posit that expansion of the balance sheet can be effective when overnight interest rates are close to zero. Through purchases of government bonds along with shifting the maturity structure to longer-dated securities, the size of the central bank's balance sheet can reduce their yields to stimulate economic performance.

By comparison to other central banks, the Japanese experience with balance sheet

[1] `www.federalreserve.gov/monetarypolicy/bstrecenttrends.htm`.

[2] See Pandl (2012), Meyer and Bomfim (2012), and Li and Wei (2012) for studies on the cumulative effects of asset purchase programs.

policies began in the Spring of 2001 – a much longer timeframe than other countries. Similar to recent observations, Ueda (2012) and Takeda and Yajima (2014) provide evidence that such policies led to a decline in long-term yields of Japanese government bonds as well as in the returns of other privately-issued assets.

Given the extensive use of balance sheet policies in recent years and the possibility that they may be pursued in the future, the objective of this paper is to develop a framework to study the size of the balance sheet as well as other policies designed to affect long-term interest rates.[3] In so doing, I seek to study the transmission channels of conventional monetary policies such as the money growth rate in comparison to "unconventional" balance sheet policies. I am particularly interested in the effects of the various policy tools on investment, capital formation, and the yield curve. In our framework, the fiscal authority issues riskless short and long-term bonds. In the absence of purchases from the monetary authority, financial intermediaries buy the bonds from the fiscal authority on behalf of their depositors. By comparison, the central bank prints money over time and can also acquire bonds.

Central bank actions – whether conventional monetary policies or unconventional balance sheet policies – affect economic activity through the incentives of intermediaries in the banking system. Therefore, one cannot understand the transmission channels of policy in the absence of well-defined intermediaries who perform services that depositors cannot achieve individually. In particular, Diamond and Dybvig (1983) demonstrate that intermediaries perform important risk-pooling functions. Further, Bencivenga and Smith (1991) show that risk-pooling institutions economize on holdings of unproductive liquid assets. Thus, it naturally follows that unconventional policies - with an emphasis on purchases of long-term securities - can be best understood in a framework where intermediaries favor long-term investment opportunities. Finally, in order to study the effects of conventional policies such as money growth, it is also important that a model feature a well-defined transactions role for money as a medium of exchange.

In order to study the effects of conventional versus "unconventional" balance sheet

[3]This is especially true for the case of the European Central Bank.

policies for economic outcomes, I consider an overlapping generations version of Diamond and Dybvig (1983) with production as articulated by Bencivenga and Smith (1991). In addition, following Schreft and Smith (1997, 1998), limited communication and restrictions on asset portability lead to a well-defined transactions role for money. In our framework, a fraction of individuals in the economy will be randomly relocated to another geographic location. Due to the friction of limited communication across locations, these individuals must hold fiat money in order to realize consumption. In this manner, the liquidity risk is analogous to a liquidity preference shock as in Diamond and Dybvig. Financial intermediaries exist to provide insurance against such shocks by providing risk pooling services.

There are two significant departures in our framework from the previous literature. First, in order to study asset purchases of both short and long-term bonds, I extend our model to a three period overlapping generations setup. Second, the fiscal authority and the central bank are separate institutions. Only a fraction of central bank net revenues will be redistributed back to the fiscal authority in each period. Consequently, asset purchases by the central bank can have an effect on yields of government debt. In turn, the reduction in yields has the potential to promote income and capital accumulation.

Our framework clearly articulates the following transmission channels of conventional policy versus balance sheet policy.[4] First, money growth affects economic activity by generating seigniorage revenue. It also interrupts risk-sharing. By comparison, a second conventional policy – open market operations targeted towards short-term government bonds – attempts to discourage institutions from providing risk-sharing to depositors. As a result, it promotes capital formation as more resources are devoted to investment in productive assets. Finally, balance sheet policy targeted towards long-term government bonds reflects the desire to lower long-term yields to push institutions away from unproductive government debt.

Interestingly, the framework demonstrates that outright open market operations through purchases of short-term government securities unambiguously lower yields and promote

[4]Bhattacharya and Singh (2008, 2010) compare the effects of a money growth rule to an interest rate target.

economic activity. By comparison, long-term asset purchases are only effective if short-term yields are sufficiently low. Should central bankers in countries with high debt loads and high short-term interest rates implement a long-term asset purchase program, it will be ineffective as it would only encourage fiscal authorities to issue more debt. In this manner, our work contributes to a number of recent papers that show that the effects of monetary policy are likely to vary across countries. For example, Ghossoub and Reed (2010) develop a framework that demonstrates that the effects of money growth are qualitatively different between rich and poor countries. In particular, monetary policy generates a Tobin effect in advanced countries but reduces economic activity in poor countries. Moreover, Bullard and Keating (1995) observe that money growth positively affects output in low inflation countries. In contrast to previous work studying the effects of conventional policy across countries, I also find that the effects of unconventional policy vary.

From a methodological perspective, there are two papers that are closely related to our work. First, Schreft and Smith (1997) develop a monetary growth framework with multiple steady-states in which the amount of government debt varies. As a result of the different levels of government debt which crowd out capital formation, the effects of monetary policy vary across countries. In comparison to their work, the fiscal and monetary authorities are "independent" institutions in our model. In particular, the central bank acquires government bonds which are issued by the fiscal authority. In their model, bonds are issued by a hybrid fiscal-monetary authority and only private intermediaries hold government debt. While Schreft and Smith (1997) focus on the crowding-out effects of government debt, purchases of securities by the central bank may relieve the crowding-out problem in our framework.

By comparison, Schreft and Smith (2002) study how the stock of government debt affects the ability of the monetary authority to conduct open market operations. Finally, both Schreft and Smith (1997) and Schreft and Smith (2002) construct two-period OLG models while I consider a three-period framework so that I can study yields of government debt at different maturities.

The remainder of the paper is as follows. As a simple starting point, Section 2 establishes a model of two periods in order to focus exclusively on the size of the balance sheet in comparison to a standard money growth rule. Section 3 extends the model to three periods. Section 4 studies steady-states in the three period framework. Section 5 compares the effects of different monetary policy instruments and Section 6 concludes.

2.2 Benchmark Model of Treasury Purchases

I begin by establishing a benchmark model that will allow us to analyze the effects of a conventional policy tool – changes in the money growth rate. By comparison, I also analyze asset purchases of the central bank. The relatively simple two period structure highlights the distinction between activities of the fiscal authority from the central bank (CB). Notably, the fiscal authority and the central bank are separate institutions. Only a fraction of central bank net revenues will be redistributed back to the fiscal authority in each period. It also allows us to focus on the implications of large-scale open market operations in a setting where all bonds have the same maturity. In comparison to Schreft and Smith (2002), I consider that the monetary authority retains a proportion of its revenues.

Moreover, I allow for the CB to use two different policy tools. As in Schreft and Smith (2002), the CB can purchase government securities. In addition, in our framework, the monetary authority prints money over time following a fixed money growth rule. In this manner, there are two different ways in which the monetary authority influences the ability of private sector intermediaries to achieve risk-sharing.

Finally, the transmission of policy actions of the CB in Schreft and Smith (2002) are limited as they only study an endowment economy. Instead, I investigate the impact of CB activities in a production economy with capital accumulation.

2.2.1 The Environment

Time in the economy is discrete, indexed by $t = 1, 2, ...\infty$. Two geographically-separate locations coexist. Each is populated by a unit-mass continuum of two-period lived agents that exert labor effort when "young" and value consumption of a homoge-

neous good when "old". Given an initial population of old, the economy is populated by an infinite stream of individuals within each location such that an overlapping generations structure prevails. Agents' preferences are $u(c_t) = \log c_t$ and they are endowed with one unit of labor when young. In every period, each young agent has a probability $\pi \in (0, 1)$ of moving to the other location.

The banking sector is represented by a market for deposits in which private banks accept agents' labor income in exchange for a return at a future date. Moreover, the market for deposits is perfectly competitive. Consequently, each intermediary will offer rates of return to maximize depositors' expected utility.

Following Schreft & Smith (1997), there is limited communication between banks at different locations. The resulting anonymity friction eliminates the possibility of trading privately issued liabilities. Only fiat money can be transported between locations. Thus, movers must liquidate their savings and carry money balances to their new site despite that money is dominated in rate of return by all other assets in the economy.

Due to the potential for geographic displacement, individuals are subject to relocation risk. Since relocation shocks force individuals to liquidate their asset holdings early, relocation shocks are analogous to liquidity preference shocks in Diamond and Dybvig (1983). Intermediaries provide insurance against such risk by pooling income and offering returns on deposits contingent on relocation status. As the banking sector is perfectly competitive, institutioejindu umens will offer a level of risk-sharing that maximizes depositors' expected utility.

There are separate fiscal and monetary authorities. The fiscal agent generates its stream of revenue from issuing risk-free bonds B_t in financial markets as well as from supplementary transfers by the monetary authority. Letting the real value of bonds be $b_t \equiv B_t/P_t$ where P_t is the unit price of the consumption good, a holder of a unit of government debt at $t-1$ has a sure claim to R_t units of consumption in period t. Hence, debt payouts constitute the liability side of the fiscal authority.

The CB implements policy based on two instruments. First, it controls the supply of money in the economy according to the rule $M_t = \sigma M_{t-1}$ where M_t denotes the period

t nominal money supply per agent and $\sigma > 1$ the gross rate of money growth between adjacent periods. Real money balances, $m_t \equiv M_t/P_t$, offer a rate of return that depends on the economy's relative price level $\frac{P_{t+1}}{P_t}$.

The second instrument derives from the CB's ability to engage in an active bond purchase program. Consequently, total demand for government debt in the economy will be split between the CB and private banks. A constant fraction $\lambda \in [0, 1]$ of net revenue that is generated by the CB will be transferred to the fiscal entity in every period. I consider this value as an "institutional" parameter which reflects the degree of resource-independence of the CB.

2.2.2 Factor Markets

Labor (L_t) and capital (K_t) are the two factors of production in the economy. Labor effort is exclusively provided by young agents. Capital earns a rate of return of r_t and completely depreciates at the end of each period. As in the neoclassical growth model, output of a homogeneous consumption good is realized through a constant returns to scale production technology $F(K_t, L_t)$. In standard capital-intensive form it is $f(k_t)$, where $k_t \equiv K_t/L_t$, $f'(k_t) > 0$ and $f''(k_t) < 0$.

Due to perfect competition in each factor market, each input earns their marginal product:

$$w_t = w(k_t) = f(k_t) - k_t f'(k_t) \tag{2.1}$$

$$r_t = f'(k_t), \tag{2.2}$$

and I assume $w(0) > 0$.

2.2.3 Timing of Actions

The timing of events that take place within an agent's two-period life span is illustrated in figure 2.1. Young individuals provide labor effort and production takes place. Afterwards, factors of production get paid according to (2.1) and (2.2) from which young

workers deposit all of their labor income in private banks.

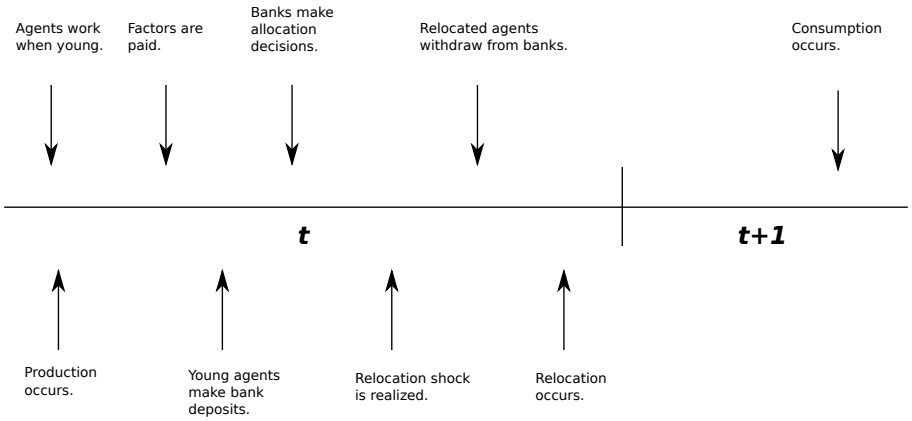

Figure 2.1: Benchmark model: depositor's timing of actions (Schreft & Smith, 1997).

Because the fraction of young individuals that are going to relocate is publicly known, banks determine the optimal allocation of deposits into currency and other assets during this phase. At the end of the initial period when the relocation shock π is observed, every young depositor who needs to move withdraws their deposits. However, due to limited communication and restrictions on asset portability, movers will only demand cash. At the end of this first period relocation occurs. When period $t+1$ arrives, old nonmovers withdraw deposits whereas their moving counterparts exchange cash for the consumption good with banks in their new location. Finally, all old agents consume and exit the economy at the end of the period.

2.2.4 Financial Intermediation

All banks are identical so I focus on a single representative bank that offers returns on deposits. A bank can participate in the market for deposits by offering rates of return to its clients as dictated by a perfectly competitive financial sector. Together with the assumption of zero transaction costs, the profit maximization program for this institution translates into expected utility maximization on behalf of its depositors.

Consequently, banks compete for deposits w_t by announcing a rate of return r_t^m for the π movers and r_t^n for the remaining $(1-\pi)$ non-movers. Therefore, the consumption available to each agent is:

$$c_t^m = w_t r_t^m \tag{2.3}$$

if a mover, and

$$c_t^n = w_t r_t^n, \tag{2.4}$$

for a nonmover.

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Banks allocate deposits into the three different assets in the economy: real money balances in the amount m_t, capital per depositor i_t and government issued bonds b_t^P such that:

$$m_t + i_t + b_t^P \leq w_t. \tag{2.5}$$

Moreover, banks face additional constraints in order to guarantee that the actual returns are in line with those offered to the moving and nonmoving populations. That is, for those who relocate, it must be that

$$\pi w_t r_t^m \leq m_t \frac{p_t}{p_{t+1}} \tag{2.6}$$

and

$$(1-\pi) w_t r_t^n \leq r_t i_t + R_t b_t^P \tag{2.7}$$

otherwise. Under this scenario, the representative bank's optimization program is

$$\max_{r_t^m, r_t^n} \{\pi \ln [w_t r_t^m] + (1-\pi) \ln [w_t r_t^n]\}$$

subject to (2.5) - (2.7).

The solution to this maximization problem yields the following first order conditions:

$$R_t - r_t = 0. \tag{2.8}$$

and

$$m_t / w_t - \pi = 0. \tag{2.9}$$

Equation (2.8) is a no-arbitrage condition that makes bank's investment allocations indifferent between bonds and capital. The efficient risk-sharing condition in (2.9) allows banks to insure agents against liquidity risk by allocating a relative amount of cash balances equal to the fraction of moving individuals. In this manner, banks contribute to the agent's welfare by risk-pooling.

2.2.5 The Central Bank

Monetary policy is the sole responsibility of the monetary authority. As previously mentioned, it has two types of instruments: the growth rate of money as its conventional policy tool and the acquisition of government debt obligations. In any given period, the CB follows a constant money growth rule so that inflation generates seigniorage revenue equal to $\left(\frac{\sigma-1}{\sigma}\right) m_t$. The CB also participates in financial markets by purchasing government bonds in the amount b_t^{CB}. In addition, the CB transfers a fraction λ of its net revenue to the fiscal authority in every period. Through this resource injection, the CB can have an indirect influence on the impact of fiscal debt in the economy. Recalling R_t as the return on government securities, the CB's resource constraint is

$$R_{t-1} b_{t-1}^{CB} + \left(\frac{\sigma - 1}{\sigma}\right) m_t - b_t^{CB} \geq 0. \tag{2.10}$$

The first two terms in (2.10) represent the revenues from the return to bonds and seigniorage revenue. The third term depicts expenses incurred in the purchase of government debt during the same time period. As noted in (2.10), I do not allow the central bank to impose net losses upon the fiscal authority.

2.2.6 The Fiscal Authority

The fiscal authority in this economy issues riskless government bonds b_t in financial markets. As pointed out above, demand for these assets comes from private banks and from the CB so that the bond market clearing condition becomes:

$$b_t = b_t^P + b_t^{CB}, \quad \text{for all} \quad t > 0. \tag{2.11}$$

The government obtains its income from the sale of debt obligations as well as from CB

transfers. Specifically, the latter represents an injection of a fraction (λ) of the CB's net receipts as depicted in (2.10). Similarly, the expense side of the fiscal authority's budget constraint consists of payments disbursed to honor its debt obligations at maturity. In equilibrium, government revenue equals expenses so that:

$$R_{t-1}b_{t-1} = b_t + \lambda[R_{t-1}b_{t-1}^{CB} + \left(\frac{\sigma - 1}{\sigma}\right) m_t - b_t^{CB}], \quad \text{for all} \quad t > 0. \tag{2.12}$$

2.2.7 Steady State Equilibrium

I now study economic activity in steady-state. First, currency as well as bond markets clear by equations (2.9) and (2.11), respectively. In addition, I also have $i_t = k_{t+1}$. Consequently, using the private bank's balance sheet it must be that

$$k_{t+1} = w_t - m_t - b_t^P \quad \text{for} \quad t \geq 0, \tag{2.13}$$

which highlights that in private bank's portfolios, investment in capital declines as demand for liquidity or government debt increases. Next, using the fiscal authority's budgetary constraint (2.12) along with (2.9) and (2.11), I can solve for the amount of government bonds purchased by private banks, b_t^P which yields

$$b_t^P - (1 - \lambda)b_t^{CB} = \lambda \left(\frac{\sigma - 1}{I_t - \sigma}\right) m_t, \tag{2.14}$$

where $I_t \equiv \frac{P_{t+1}}{P_t} R_t$.

A closer look at the results allows us to see two important aspects related to fiscal debt. First, the CB can absorb government debt that otherwise would be acquired by private banks. This implies that the monetary authority has a tool that can act as a buffer for government debt distortions. Notably, the amount of bonds available for the private sector to hold depends on the degree of resource-independence of the monetary authority. For example, if $\lambda = 1$, then effectively all of the bonds issued by fiscal authority would be held by the private sector. In this case, though the central bank may hold bonds, it redistributes everything back to the fiscal authority. So, in net terms, the fiscal authority would not have any debt obligations to the CB. Moreover, all of the debt would be

financed by seigniorage. As the CB retains more of its revenues (λ smaller), there would be less bonds available for intermediaries to purchase.

Second, the relationship between seigniorage and bond holdings also depends on the degree of independence. The relationship between seigniorage and bonds held by the private sector is increasing in λ. That is, the extent of inflation-financing of debt is higher if the CB transfers more of its revenues to the fiscal authority.

Next, (2.14) into (2.13) yields:

$$\Omega(k) = \frac{(1-\pi)(I_1 - \sigma) - \lambda\pi(\sigma - 1)}{I - \sigma} + (1-\lambda)\frac{b^{CB}}{w(k)}, \tag{2.15}$$

where $\Omega(k) \equiv k/w(k)$ and I assume $w_0 \equiv w(0) > 0$, so that $\Omega'(k) > 0$ for $k \geq 0$. If $\lambda = 1$, the government budget constraint would be the same as Schreft and Smith (1997).

This analysis also differs from their study in another important aspect. Focusing on the share of capital to deposits, CB asset purchases have two effects. On one hand, they contribute to capital formation by reducing the crowding out effect. On the other, as economic activity increases, intermediaries now have a higher level of deposits. Hence, the effects of this policy on the share of capital in private banks' balance sheets must be controlled for the size of the deposit base. Thus, the behavior of (2.15) in relation to any policy that stimulates capital formation must take into account this additional effect.

Equation (2.15) shows the steady state level of capital in the economy depending explicitly on the rate of money growth and bond purchases by the CB. Additionally, the stock of capital is negatively affected by the nominal return on government debt. As increasing debt levels imply higher borrowing costs for the fiscal authority, a potential pathway for a crowding out effect remains.

I also have a no-arbitrage condition as described by (2.8) in steady-state. Money market equilibrium along with the money growth rule implies $\sigma = P_{t+1}/P_t$. From the capital market condition, (2.2), and (2.8), the no-arbitrage condition is:

$$I = \sigma f'(k) \tag{2.16}$$

Together, (2.15) and (2.16) capture the complete steady-state equilibrium behavior of the economy.

The following proposition provides the conditions for multiple steady states to exist:

Proposition 1. (*Existence of Multiple Steady-States*). *Suppose that the condition in (2.10) holds. In addition, let* $\hat{k}$ *be such that* $\Omega(\hat{k}) = 1 - \pi(1-\lambda) + (1-\lambda)b^{CB}/w(\hat{k})$ *and* $\hat{\sigma} = 1/f(\hat{k})$. *Further, suppose that* $\sigma > \hat{\sigma}$. *Under these conditions, multiply steady-states exist in which the financial position of the fiscal authority varies. In the low capital steady-state, the fiscal authority is a net debtor. In the other steady-state, the fiscal authority transfers income to the private sector.*

Figure 2.2 illustrates the existence of multiple steady state equilibria in the model. Interestingly, each steady-state has distinct features. In equilibrium A for instance, a highly distorted economy prevails as characterized by a low level of capital and high nominal interest rates. As explained in Schreft & Smith (1997), this steady state resembles a developing economy with a high amount of outstanding government debt. Particularly, looking at (2.14) in steady state and because $I > \sigma$ in this regime, there is a positive amount of bonds outstanding that makes the government hold a net-debtor position in financial markets.

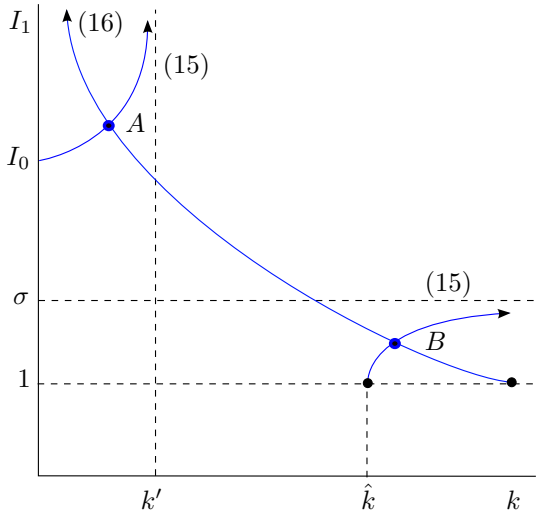

Figure 2.2: Benchmark model: steady state equilibria.

In contrast, the economy represented by the equilibrium shown in B exists in a more efficient financial sector with a low interest rate and high capital stock. If the prevailing interest rate I has an upper bound $I < \sigma$, the fiscal authority holds a net lending position as in Schreft and Smith (1997).

2.2.8 Comparative Statics

Money Growth Rule

I begin the analysis by illustrating how the effects of a money growth rule policy transmit to the real sector. Proposition 2 summarizes the implications of a higher rate of money growth for activity across steady-states:

Proposition 2.

i. In economies where the government is a net debtor, $\frac{dk}{d\sigma} < 0$, $\frac{dR}{d\sigma} > 0$, *and* $\frac{dI}{d\sigma} > 0$.

ii. In economies where the government is a net creditor, $\frac{dk}{d\sigma} > 0$, $\frac{dR}{d\sigma} < 0$, *and* $\frac{dI}{d\sigma} > 0$.

Figure 2.3 shows the two differing outcomes depending on the steady-state. In the economy where the government is a net debtor, an increase in the rate of money growth enhances the government's ability to issue debt. However, due to (2.11), the bond market clears so that an increased bond supply gives way to higher nominal yields which ultimately crowd out capital accumulation. In contrast to Schreft and Smith (1997), the increase in nominal interest rates and the reduction in the capital stock will be higher if the CB is less "independent." That is, the crowding-out effect will be larger if the CB transfers a greater proportion of its revenues to the fiscal authority.

In the economy where the government is a net lender, a low-interest rate steady state regime, an increase in σ contributes to capital formation. Since nominal interest rates are sufficiently low, as the government is subsidizing economic activity through its net lending status, an increase in the rate of money growth erodes the real return on bonds which promotes the ability of intermediaries to invest in capital. Again, the effects are stronger as λ is larger.

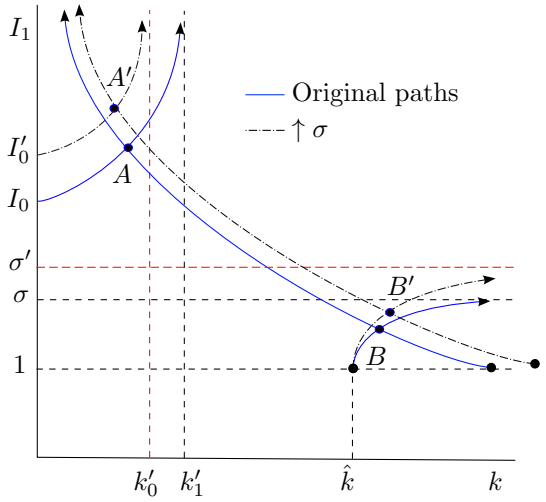

Figure 2.3: Benchmark model: money growth policy.

Treasury Purchase Program

When the CB engages in a bond purchase program, there are nontrivial effects on capital formation. Proposition 3 summarizes the implications of an increase in bond purchases:

Proposition 3. *Regardless of the fiscal position of the government,* $\frac{dk}{db^{CB}} > 0$, $\frac{dR}{db^{CB}} < 0$, *and* $\frac{dI}{db^{CB}} < 0$.

Unlike a money growth instrument, purchases by the CB unambiguously increase capital formation in both steady states. In the low capital economy, the policy action reduces the supply of government debt available to private investors. Therefore, it alleviates the crowding out problem of inflation-financed government debt. This allows a lower rate of marginal productivity to drive down nominal interest rates throughout the economy in the absence of arbitrage opportunities.

Within the high capital economy where the cost of borrowing is lower than the inflation rate, an expansion in the balance sheet acts as an increase in loans to the fiscal authority at a low interest rate. The "low cost" borrowing translates into additional resources available for private investment. In turn, the actions of the CB promote capital formation. Figure 2.4 illustrates the findings. In comparison to the effects of money growth, the effects of open market operations are stronger when there is a greater degree of independence of the monetary authority from the fiscal authority.

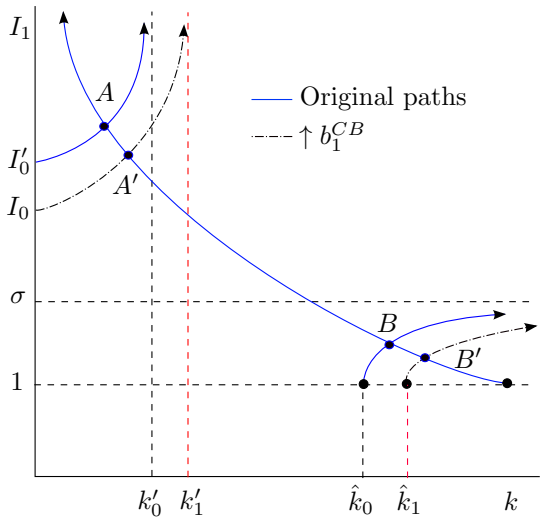

Figure 2.4: Benchmark model: short-term bond purchases.

Notably, I find that conventional money growth policy has distinct implications for risk-sharing relative to unconventional policy. First, an increase in the rate of money growth lowers the return on money which distorts the level of risk-sharing in the economy regardless of the steady-state. However, as the real return to government debt is lower in response to higher money growth in the advanced steady-state, the implications for risk-sharing are less severe in advanced economies. However, unconventional balance sheet policy promotes welfare without the negative implications for the return to money. From this perspective, open market operations may be a preferable tool relative to money growth since it promotes activity without disturbing risk-sharing in the financial system.

2.3 A 3-Period Model

Having shown the reach of the benchmark model, I now proceed to enrich its structure with the aim of analyzing unconventional monetary policy measures.

As these actions constitute an expansion of the CB's balance sheet through the purchase of longer-term government securities, I allow for the existence of such assets by including an additional period in the life cycle of agents. Specifically, I use a three-period overlapping generations structure that allows the fiscal authority to issue short-term (one-period) and long-term (two-period) bonds.

2.3.1 The Environment

The unit-mass continuum of individuals experience three stages. Now, after a young stage, an intermediate "middle-age" follows which then leads to their last existing period or old phase. There is an initial population of each type for which only the old agents hold M_0 units of currency. Labor effort is still provided when young and consumption valued when old. In this three-period setup, relocation shocks are experienced by middle-aged depositors.

While the fiscal authority continues to issue one-period or short-term real bonds which I now denote as $b_{1,t}$ with rate of return $R_{1,t}$, it also sells long-term, two-period maturity bonds in amount $B_{2,t}$ with real value $b_{2,t} \equiv B_{2,t}/P_t$. A holder of a unit of this security at period t is entitled to $R_{2,t+2}$ units of the consumption good in period $t+2$.

Therefore, the CB has a third instrument that belongs to its set of balance sheet tools, namely, purchases of long-term government securities in amount b_2^{CB}. Together with outright open market operations (described now by b_1^{CB}) and control of the money growth rate, the CB implements monetary policy.

2.3.2 Factor Markets

I preserve the production technology studied in the benchmark model. However, investment in capital takes two periods to materialize. This implies that returns to inputs follow:

$$r_t(k_t) = f'(k_t) \tag{2.17}$$

and

$$w_t \equiv w_t(k_t) = f(k_t) - k_t f'(k_t). \tag{2.18}$$

2.3.3 Timing of Actions

Following the timeline described in Figure 2.5 the supply of labor, return to factors, bank deposits and their corresponding investment allocations take place in an individual's first period. As the middle aged period arrives, agents learn their relocation status. Then movers liquidate their savings from banks and exchange them for cash with the previous

generation's old movers and relocation takes place. This action marks a difference relative to our benchmark in that the bank does not explicitly hold cash balances. Finally, when old, agents realize consumption based on returns to assets and exit the economy.

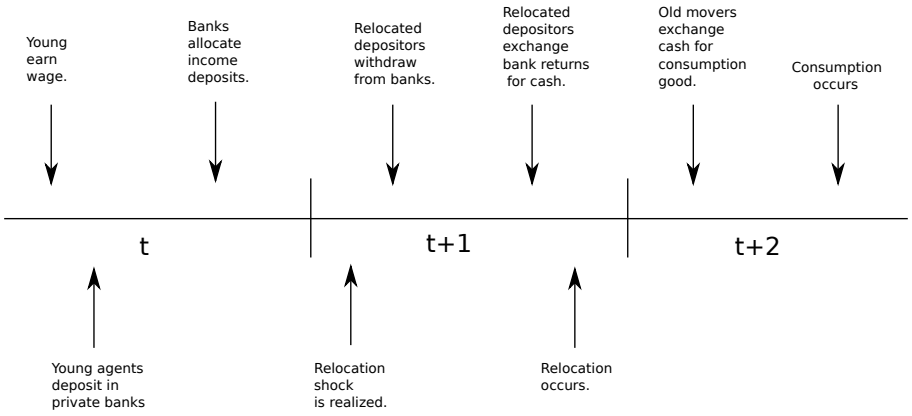

Figure 2.5: Depositor's timing of actions

2.3.4 Financial Intermediation

Private banks create portfolios of capital i_t and bonds (both short-term and long-term maturities $b^P_{1,t}$ and $b^P_{2,t}$, respectively). In turn, the nominal return to government debt is $I_{1,t} \equiv R_{1,t}(P_{t+1}/P_t)$ if short-term and $I_{2,t} \equiv R_{2,t}(P_{t+2}/P_t)$, otherwise.

The distribution of asset holdings among depositors depends upon their liquidity preference. Notably, in contrast to standard Schreft-Smith (1997, 1998) models there is a short-term, interest-bearing asset that intermediaries can acquire in order to meet demands among those who withdraw early. The amount acquired on behalf of movers is equal to $b^m_{1,t}$. However, there is still an information friction that such individuals will eventually need to confront. That is, upon receiving their payments from bond holdings in the short-term, middle-aged movers will buy cash from old individuals who are carrying cash from the other location. Thus, in contrast to Schreft-Smith (1997, 1998), money is primarily a medium of exchange since there is an alternative short-term interest bearing asset available.

The returns of nonmovers come from both short and long-term bonds ($b^n_{1,t}$ and $b^n_{2,t}$) along with capital i_t. In this manner, a representative bank offers a rate of return on deposits of r^m_t if relocating and r^n_t otherwise. Therefore, consumption for movers is:

$$c_t^m = r_t^m w_t \tag{2.19}$$

and

$$c_t^n = r_t^n w_t \tag{2.20}$$

for nonmovers.

The private bank's balance sheet constraint is:

$$w_t = b_{1,t}^m + b_{1,t}^n + b_{2,t}^n + i_t. \tag{2.21}$$

Similarly, payments to movers are constrained by:

$$\pi w_t r_t^m = \left(R_{1,t+1} b_{1,t}^m\right) \frac{P_t}{P_{t+1}}, \tag{2.22}$$

whereas for the nonmoving depositors:

$$(1-\pi) w_t r_t^n = \left(R_{1,t+1} b_{1,t}^n\right) R_{1,t+2} + R_{2,t+2} b_{2,t}^n + r_{t+2} i_t, \tag{2.23}$$

Based on these conditions along with (2.19) and (2.20), banks offer deposit rates that solve

$$\max_{r_t^m, r_t^n} \left\{\pi \ln\left[w_t r_t^m\right] + (1-\pi) \ln\left[w_t r_t^n\right]\right\} \tag{2.24}$$

subject to (2.19) - (2.23). In turn, the solution to the bank's problem yields the following first order conditions:

$$R_{2,t+2} - r_{t+2} = 0 \tag{2.25}$$

$$R_{1,t+1} R_{1,t+2} - r_{t+2} = 0 \tag{2.26}$$

where (2.25) establishes that optimal bank allocations in long term bonds and capital eliminate arbitrage opportunities. Likewise, (2.26) shows that compounded short term

bond returns must be the same as capital. Combining these two conditions provides a no-arbitrage condition among bonds with different maturities:

$$R_{1,t+1}R_{1,t+2} = R_{2,t+2}. \tag{2.27}$$

Equation (2.27) represents the basis for a term structure of interest rates that underlies the yield curve in the economy.

By solving (2.24), the private bank's optimal allocation of short term bonds for movers is:

$$b_t^m = \pi w_t, \tag{2.28}$$

which yields both the private bank's short-term bond demand and the optimal risk sharing rule. Real returns from debt are used to purchase real money balances from the current old movers:

$$m_{t+1} = R_{1,t+1}b_{1,t}^m. \tag{2.29}$$

2.3.5 The Central Bank

The CB controls the rate of money growth which allows for seigniorage revenue as well as the implementation of open market operations. In this economy however, the monetary authority is able to access a third policy instrument. In particular, it can also acquire long-term bonds equal to $b_{2,t}^{CB}$. Therefore, the CB's resource constraint is:

$$R_{1,t-1}b_{1,t-1}^{CB} + R_{2,t-2}b_{2,t-2}^{CB} + \left(\frac{\sigma-1}{\sigma}\right)m_t - b_{1,t}^{CB} - b_{2,t}^{CB} \geq 0. \tag{2.30}$$

2.3.6 The Fiscal Authority

Fiscal debt obligations can be redeemed within one or two periods depending on their maturity structure. The supply of short-term bonds issued by the fiscal authority is $b_{1,t}$. Short-term bond demand on behalf of movers and non-movers is $b_{1,t}^m + b_{1,t}^n$. In addition, holdings by central bank are equal to $b_{1,t}^{CB}$. Thus, the clearing condition for short-term

bonds implies:

$$b_{1,t} = b_{1,t}^m + b_{1,t}^n + b_{1,t}^{CB} \tag{2.31}$$

On the other hand, the demand for long-term bonds only comes from two sources: the demand by intermediaries on behalf of the non-movers ($b_{2,t}^n$) and the demand by the central bank ($b_{2,t}^{CB}$):

$$b_{2,t} = b_{2,t}^n + b_{2,t}^{CB}. \tag{2.32}$$

At any time period, the government budget is balanced so that

$$\begin{aligned} b_{1,t} + b_{2,t} + \lambda \left[R_{1,t-1} b_{1,t-1}^{CB} + R_{2,t-2} b_{2,t-2}^{CB} + \left(\frac{\sigma - 1}{\sigma} \right) m_t - b_{1,t}^{CB} - b_{2,t}^{CB} \right] = \\ R_{1,t-1} b_{1,t-1} + R_{2,t-2} b_{2,t-2}. \end{aligned} \tag{2.33}$$

2.3.7 Steady-State Analysis

From the bank's demand for short-term bonds (2.28) and since $i_t = k_{t+2}$ I rewrite its balance sheet constraint (2.21) in the steady-state as:

$$k = w(1 - \pi) - b_1^n - b_2^n. \tag{2.34}$$

Again, there is potential displacement of capital in bank's portfolios from government debt. However, bond market equilibrium conditions (2.31) and (2.32) show that the CB can affect the magnitude of such displacement.

To see how acquisitions by the monetary authority impact private bond demand, I focus on the fiscal authority's constraint (2.33). The no-arbitrage condition on real interest rates (2.27) along with $\sigma = P_{t+1}/P_t$ in the steady state, yields the no arbitrage condition between nominal interest rates:

$$(I_1)^2 = I_2. \tag{2.35}$$

It follows that equation (2.33) can be arranged as:

$$b_1^n + b_1^m + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^n + (1-\lambda)\left[b_1^{CB} + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^{CB}\right] = \lambda\left(\frac{\sigma-1}{I_1-\sigma}\right) m, \qquad (2.36)$$

so that the total amount of government obligations is equal to current revenues.

In this manner, the LHS of (2.36) shows government outstanding liabilities - net of CB transfers - in the form of short and long-term bonds. These securities are held by private banks and the monetary authority. As denoted by the RHS of this constraint, bonds are financed via seigniorage revenue transfers relative to the net interest obligations of the fiscal authority. It is evident that the degree of redistribution of income from the central bank (implied by λ) and central bank bond purchases play a significant role in the fiscal authority's actions. In what follows, I analyze the interaction between the fiscal and the monetary authority.

First, following the risk-sharing rule from (2.28), private banks allocate movers' deposits into government debt $b_1^m = \pi w$. Upon receiving returns from their bond holdings, movers acquire money balances in the amount $m = R_1(\pi w)$. Also, using (2.16) I can substitute these values into (2.36) and rearrange it so that:

$$b_1^n + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^n + (1-\lambda)\left[b_1^M + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^{CB}\right] = \pi w\left[\lambda\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{I_1}{I_1-\sigma}\right) - 1\right]. \qquad (2.37)$$

Now, after taking into account the risk-pooling actions of intermediaries, government expenses involve debt liabilities to private banks as well as to the monetary authority. However, the term on the right hand side now represents net seigniorage revenue.

I begin by considering economies in which $I_1 < \sigma$. In this scenario, the RHS of (2.37) is negative which implies that the fiscal authority – on net – transfers income to the private sector. This is possible because the fiscal authority earns more income from seigniorage than it pays for its bonds. Should the monetary authority engage in a bond purchase

program, this provides the fiscal agent with more resources to redistribute to the private sector.

In Schreft and Smith (1997), the government is a net debtor if $I_1 > \sigma$. However, they do not allow for the government to issue bonds of different maturities as in our model. The additional complications arising from the maturity structure imply that stronger restrictions on short-term interest rates are required in order for the fiscal authority to persistently run as a net debtor. Interestingly, $\sigma < I_1 < \frac{\sigma}{1-\lambda\left(\frac{\sigma-1}{\sigma}\right)}$ must be satisfied.

The second inequality implies that the net revenue raised through payments by movers, $\lambda\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{I_1}{I_1-\sigma}\right)-1$, must be positive, allowing the government to run a deficit. Notably, $(I_1-\sigma)$ represents the net interest obligations of the fiscal authority from issuing bonds that will eventually be held by movers. By comparison, $\lambda\left(\frac{\sigma-1}{\sigma}\right)I_1$, is the seigniorage tax rate generated by issuing new currency to short-term bond holders. In other words, net income generated from the movers is positive as long as $\frac{\lambda\left(\frac{\sigma-1}{\sigma}\right)I_1}{I_1-\sigma} > 1$. Alternatively, the seigniorage revenue exceeds the short-term payments to movers as long as $I_1 < \frac{\sigma}{1-\lambda\left(\frac{\sigma-1}{\sigma}\right)}$. The lower bound, $I_1 > \sigma$, implies that the fiscal authority is a net debtor among the remaining bond holders.

The following corollaries shed insight into the effects of bond purchases on the fiscal authority's budget constraint:

Corollary 1. *Suppose $\lambda = 1$. Under this condition, the CB transfers all of its net revenues to the fiscal authority:*

$$b_n^{1P} + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^n = \pi w \left[\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{I_1}{I_1-\sigma}\right)-1\right].$$

As a result, all public debt is absorbed by private banks. Central bank purchases do not have any net impact on the resources of the fiscal authority.

Corollary 2. *Suppose $\lambda = 0$. In this case, the fiscal authority does not have any income:*

$$b_1^n + \pi w + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^n + b_1^{CB} + \left(\frac{I_1+\sigma}{\sigma}\right) b_2^{CB} = 0.$$

However, it is still possible that the fiscal authority issues some bonds. Zero net debt obligations implies that borrowing by the fiscal authority is offset by loans (i.e., negative bond holdings).

Proposition 4. *(Existence of Multiple Steady States) Suppose that (2.30) holds. In addition, let* $\hat{k}$ *be such that* $\Omega(\hat{k}) = (1-\lambda)b_1^{CB}/w(\hat{k}) + [\sigma + \pi\lambda + (\sigma - \lambda(\sigma+1))b_2^{CB}/w(\hat{k}) + b_2/w(\hat{k})]\sigma^{-1}$ *and* $\hat{\sigma} \equiv 1/f'(\hat{k})$*. Further, suppose that* $\sigma > \hat{\sigma}$*. Under these conditions, multiply steady-states exist in which the financial position of the fiscal authority varies. In the low capital steady-state, the fiscal authority is a net debtor. In the other steady-state, the fiscal authority transfers income to the private sector.*

I now analyze the steady-state equilibrium in the economy. Using (2.35) and (2.34) I derive the evolution of the steady state capital stock depending on the actions of the monetary authority:

$$\begin{aligned}\Omega(k) = 1 - \pi\lambda\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{I_1}{I_1-\sigma}\right) + (1-\lambda)\frac{b_1^{CB}}{w(k)} + \\ \left[1 - \lambda\left(\frac{I_1+\sigma}{\sigma}\right)\right]\frac{b_2^{CB}}{w(k)} + \left(\frac{I_1}{\sigma}\right)\frac{b_2}{w(k)}.\end{aligned} \tag{2.38}$$

I find it useful to compare (2.38) to the same equation in Schreft and Smith (1997). Notably, the analogue to Schreft and Smith (1997) in our framework would summarize the capital-deposit ratio ($\Omega(k)$) by $\Omega(k) = 1 - \pi\lambda\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{I_1}{I_1-\sigma}\right)$. If $I_1 < \sigma$, the government would be able to inject additional resources to the banking system so that investment in capital would exceed deposits. In our framework, there are *three* additional mechanisms which would encourage the same outcome. First, the central bank may inject resources to the economy in the form of one-period loans, b_1^{CB}. It may also inject resources through long-term purchases, b_2^{CB}. Finally, the fiscal authority has the ability to borrow against the future and settle its obligations in the next period instead of today.

I next provide some cursory evidence that short-term and long-term bond purchases have different effects on economic activity. Notably, the impact of long-term bond purchases hinges on the level of interest rates economy through the term $\left[1 - \lambda\left(\frac{I_1+\sigma}{\sigma}\right)\right]$.

However, the coefficient on short-term purchases is independent of interest rates.

A no-arbitrage condition between short-term bonds and long-term returns in the capital market is obtained through (2.17), (2.25), as well as the term structure depicted in (2.27):

$$I_1 = \sigma\sqrt{f'(k)}. \tag{2.39}$$

In this manner, I analyze the steady state equilibrium behavior of the economy in (I_1, k) space through (2.38) and (2.39).

Figure 2.6 shows the steady state equilibrium diagram of the economy. The existence of multiple equilibria is illustrated by points A and B. I next proceed with monetary policy analysis.

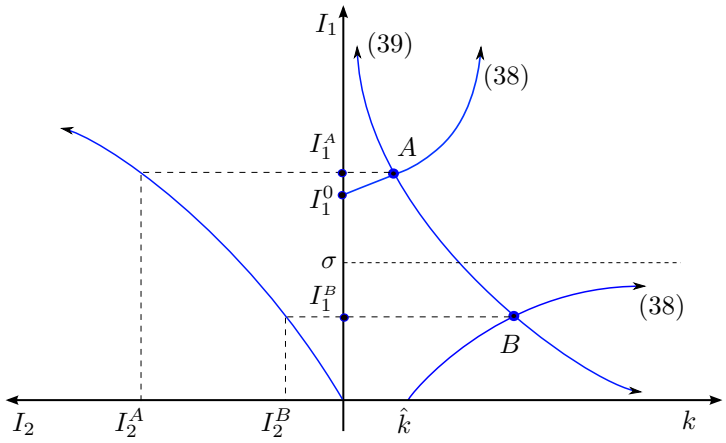

Figure 2.6: Steady state equilibria.

2.3.8 Monetary Policy Instruments: Comparative Statics

Money growth rule

I start by considering the effects of money growth for economic activity. Proposition 5 summarizes the impact of the change in the (conventional) policy:

Proposition 5.

i. In economies where the government is a net debtor, $\frac{dk}{d\sigma} < 0$, $\frac{dR_1}{d\sigma} > 0$, $\frac{dI_1}{d\sigma} > 0$, *and* $\frac{dI_2}{d\sigma} > 0$.

ii. In economies where the government is a net creditor, $\frac{dk}{d\sigma} > 0$, $\frac{dR_1}{d\sigma} < 0$, *and* $\frac{dI_1}{d\sigma} > 0$, *and* $\frac{dI_2}{d\sigma} > 0$.

Figure 2.7 illustrates the impact of an increase in σ. The capital stock in the developing economy is lower under higher money growth as seen by comparing equilibrium A relative to A'. Because the government is a net borrower, an increase in σ creates additional seigniorage income transfers. In turn, the fiscal authority can issue more debt. Consequently, the crowding out effect on the capital stock is more severe.

In the case of the high capital economy at initial steady state B, an increase in the supply of money promotes capital accumulation as denoted in B'. The increase in seigniorage promotes the ability of the fiscal authority to transfer income to the private sector.

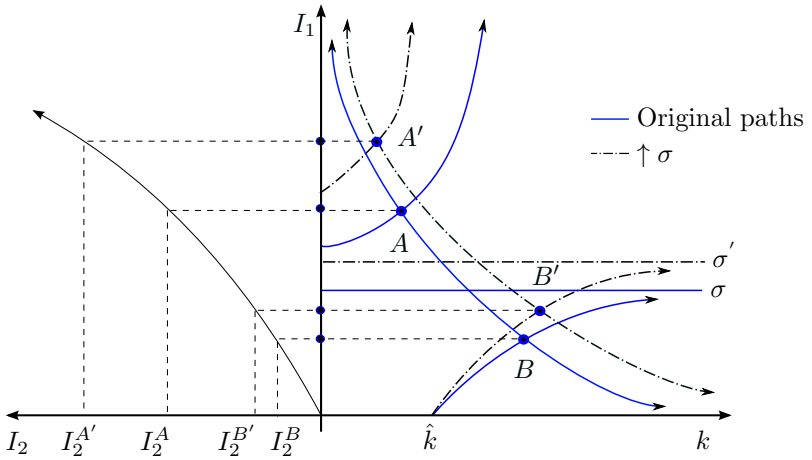

Figure 2.7: Effects of money growth rule.

Regardless of the stage of development, higher money growth leads to higher short-term nominal interest rates. By no-arbitrage across the maturity structure, long-term nominal rates will also increase. Since long-term rates are equal to the compounded short-term rate, an increase in the money growth makes the "yield curve" steeper in nominal terms. However, in the advanced economy, real interest rates are lower. From this perspective, the yield curve in real terms would become flatter.

Consequently, if the monetary authority in a poor country with a large debt service load is concerned about the cost of borrowing by the fiscal authority, an increase in the

rate of money growth (a standard monetary policy tool) would be inappropriate. However, an increase in the rate of money growth would be effective in promoting investment activity in advanced countries.

Balance sheet policy: short-term bonds

I now turn to the next conventional monetary policy - outright open market operations. Proposition 6 summarizes the effects:

Proposition 6. *Regardless of the fiscal position of the government,* $\frac{dk}{db_1^{CB}} > 0$, $\frac{dR_1}{db_1^{CB}} < 0$, $\frac{dI_1}{db_1^{CB}} < 0$, *and* $\frac{dI_2}{db_1^{CB}} < 0$.

Figure 2.8 depicts the steady state response of the capital stock and interest rates to this policy. It is clear that for both economies, open market purchases of short-term securities unambiguously increase capital formation and lower interest rates. By comparison to the effects of money growth, the yield curve will be flatter under the change in policy.

For the low capital economy, CB purchases of short term debt mitigate crowding out by absorbing government debt from private bank's portfolios. With the additional source of funding to the fiscal authority, nominal short-term interest rates do not need to be as high in order for bond markets to clear. In turn, as investment in the capital stock increases, there is a lower return to capital. This is a second-round effect of an open market operation – lower real returns lead to lower long-term interest rates due to no-arbitrage between long-term bonds and capital investment.

In the developed economy, the government transfers income to the private sector. In this case, short-term government bond purchases transfer even more funds to the fiscal authority. The low-cost resources find their way to the private sector stimulating productive investment. Then, returns to capital decrease and long-term yields decline.

Therefore, regardless of the stage of development, conventional balance sheet policy eases interest rates and promotes capital formation. In addition, the yield curve would not be as steep since long-term rates are equal to compounded short-term interest rates.

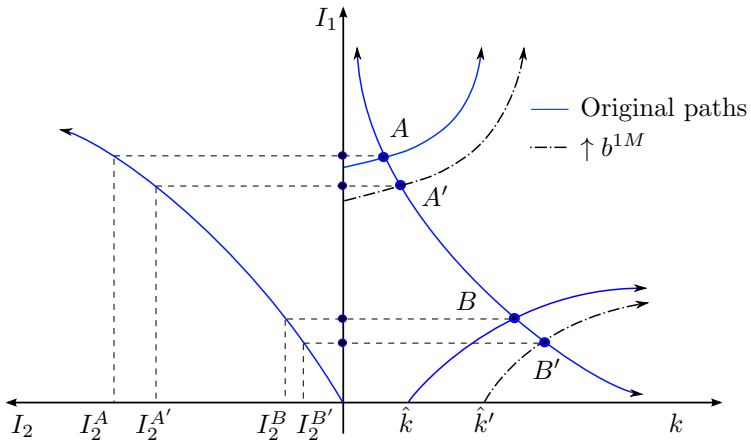

Figure 2.8: Effects of short-term bond purchases.

Balance sheet policy: long-term bonds and the yield curve

I next analyze the implications of purchases of long-term bonds. As I demonstrate below, long-term asset purchases do not necessarily improve investment and capital accumulation. That is, resources injected to the fiscal entity through long-term purchases may exacerbate fiscal distortions in the economy. For example, I start by looking at the marginal effect of b_2^{CB} on steady state capital from (2.38). Recalling that $I_1 = \sigma R_1$ I can rewrite this effect as:

$$1 - \lambda(R_1 + 1). \tag{2.40}$$

Notably, an increase in short-term purchases would be expected to promote capital formation by alleviating the distortions from the crowding-out of government debt *as long as real short-term interest rates are sufficiently low.* In terms of nominal returns:

$$1 - \lambda(\frac{I_1 + \sigma}{\sigma}). \tag{2.41}$$

As long as the coefficient is positive, long-term purchases can promote economic activity. This holds as long as:

$$I_1 < I_1^* \equiv \sigma \left(\frac{1 - \lambda}{\lambda} \right). \tag{2.42}$$

A proposition follows based on this result.

Proposition 7. *Whether the government is a net lender or net creditor,* $\frac{dk}{db_2^{CB}} > 0$, $\frac{dR_1}{db_2^{CB}} < 0$, *and* $\frac{dI_1}{db_2^{CB}} < 0$ *as long as short term interest rates are such that* $I_1 < I_1^*$.

This condition posits that long-term asset purchases are only effective in a low short-term interest rate environment. The rationale is straightforward. Asset purchases of short-term government bonds reduce the obligations to the private sector, depending on the proportion of income retained by central bank. By comparison, interest expenses for long-term bonds are *compounded* in the government budget constraint. The higher the short-term interest rate, the greater the extent of long-term interest obligations. Therefore, a long-term asset purchase program would be less effective if interest rates are high and asset purchases would not have a substantial impact on the debt obligations of the fiscal authority.

Given that the effects of long-term asset purchases are dependent on the level of short-term yields, it is unlikely that the effects of such a policy would be invariant across countries. That is, as shown in figure 2.9, the effects of long-term asset purchases are likely to depend on the stage of economic development. In a poor economy with high nominal interest rates, the supportive role of unconventional policy portrayed in Proposition 7 does not apply.

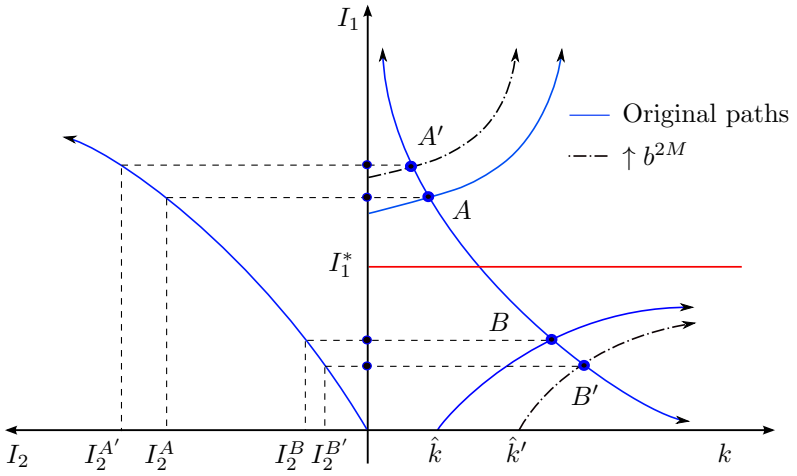

Figure 2.9: Long-term bond purchases: differential impact.

The government budget constraint involves two sources of expenditures: payments for

one-period (short-term) bonds or two-period bonds. Because of compounding, long-term bonds can be a significant drain on the obligations of the fiscal authority. As a result, long-term asset purchases of the central bank simply withdraw the less significant obligations from circulation. In this manner, long-term asset purchases aggravate the budget constraint of the fiscal authority so that the fiscal authority merely substitutes long-term debt with even greater short-term debt. The increase in short-term debt financing exacerbates the crowding-out problem.

By comparison, in an advanced country with sufficiently low short-term interest rates, the fiscal authority provides net transfers to the private sector. Should the monetary authority increase its long-term asset purchases, it is effectively lending more income to the fiscal authority. The increase in lending promotes the ability of the fiscal authority to transfer resources if short-term interest rates are low. Moreover, if short-term interest rates are low, then long-term interest rates are also low. In this manner, the increase in interest expenses to the central bank won't be enough to deter the fiscal authority from promoting capital formation. However, figure 2.10 shows that a long-term asset program would be ineffective if short-term rates are too high.

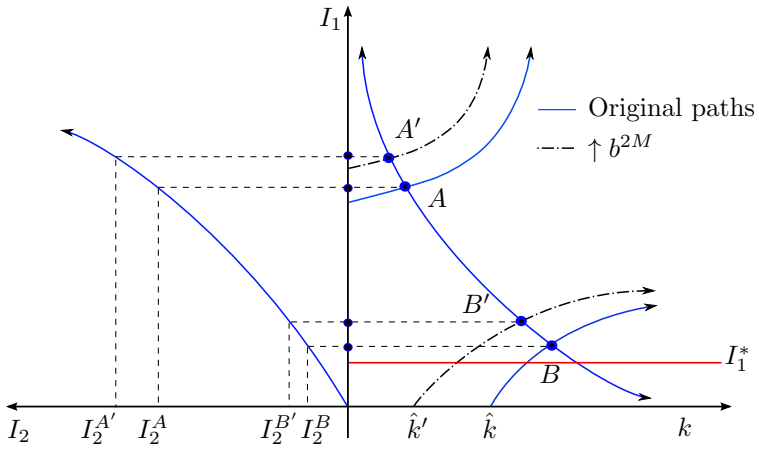

Figure 2.10: Long-term bond purchases: negative impact.

In terms of the implications for interest rates along the yield curve, both short and long-term asset purchases would cause yields to decline as long as short-term interest rates are sufficiently low. Yet, the impact of short-term asset purchases would be more effective across the maturity structure than long-term asset purchases. From this perspective,

outright open market operations promote risk-sharing in the economy more than a long-term asset purchase program. As I discussed in the simple two period benchmark, asset purchases at either part of the maturity structure are likely to be a more effective policy tool than a simple money growth rule as higher rates of money growth disturb risk-sharing.

2.4 The Information Content Behind the Yield Curve

Given the amount of attention to studying yields in recent years, I turn to the model to provide insights into the role of yields for relaying information about the state of the economy. For example, do interest rates respond more to changes in real economic activity or inflation? Does the relationship depend on the level of economic development?

As our framework is built upon inflation-financed government debt, I principally focus on the impact of productivity growth on nominal interest rates through the government budget constraint (2.38):

$$\frac{dI_1}{dA} = \frac{\frac{w_A}{w}\left[\frac{(1-\lambda)(b_1^{CB}+b_2^{CB})}{w} + \frac{I_1(b_2-\lambda b_2^{CB})}{\sigma w}\right]}{\frac{\lambda\pi(\sigma-1)}{(I_1-\sigma)^2} + \frac{b_2-\lambda b_2^{CB}}{\sigma w}} \tag{2.43}$$

By comparison, an increase in the rate of money growth would also affect interest rates:

$$\frac{dI_1}{d\sigma} = \frac{(\sigma)^{-1}\left[\frac{\lambda\pi[\sigma^2(I_1-\sigma)^2+(I_1-1)]}{\sigma(I_1-\sigma)^2} + \frac{I_1(b_2-\lambda b_2^{CB})}{\sigma w}\right]}{\frac{\lambda\pi(\sigma-1)}{(I_1-\sigma)^2} + \frac{b_2-\lambda b_2^{CB}}{\sigma w}} \tag{2.44}$$

One can easily compare the effects of productivity growth to inflation by focusing on the numerator in (2.43) and (2.44).

In terms of looking at the impact of productivity on nominal interest rates, the key factor is that an increase in productivity causes wages to increase. In turn, the increase in wages fuels deposit growth in the banking system. In order for the capital stock to remain constant, nominal interest rates must sufficiently increase in order to limit the increase in government debt. The increase is more significant if the growth rate of deposits (as

reflected by $\frac{w_A}{w}$) is higher.

Moreover, the response of interest rates depends on the amount of debt outstanding and who holds the debt, the private sector or the central bank. If $(1-\lambda)$ is higher, then the net interest obligations to the central bank would also be higher and the interest rate would need to adjust further to accommodate the increase in productivity. Second, due to similar reasoning, the adjustment is also higher if the monetary authority holds more of the debt issued by the fiscal authority. Finally, the nominal interest also increases more if the stock of long-term debt held by the private sector $(b_2 - \lambda b_2^{CB})$ is higher.

Clearly, the numerator in (2.44) depends on the impact of money growth on seigniorage revenue. If $\lambda\pi$ is higher, then the amount of seigniorage which is transferred to the fiscal authority will also be higher. The increase in revenues would fuel the ability of the fiscal authority to issue more short-term debt. Therefore, in order for the capital stock to remain constant, the nominal interest rate must rise.

Which effect is more significant? Productivity growth or money growth? The following proposition summarizes our insights:

Proposition 8. *Let $A = \sigma$. In addition, suppose that $\sigma > \frac{w_A}{w}$ and $I_1 \neq \sigma$ is such that $1 < I_1 < \tilde{I}_1$ where $\tilde{I}_1$ is defined in the Appendix. Let $\gamma \equiv \left(\frac{1-\lambda}{\lambda}\right)\left(\frac{\sigma^2 w_A}{\pi w^2}\right)(b_1^M + b_2^M)$ and $\gamma > 1$. Under these conditions, $\frac{dI_1}{dA} > \frac{dI_1}{d\sigma}$.*

According to the Proposition, the effects of productivity growth on nominal interest rates are stronger than inflation if nominal interest rates are low. From an alternative perspective, the Proposition indicates that the effects of productivity growth are stronger if the government has a large stock of bonds in circulation (which is possible if nominal costs of debt financing are low). So, the information content of interest rates clearly hinges on the level of interest rates and the fiscal position of the government.

2.5 Conclusions

The tools used by central banks have evolved considerably in recent years. One important aspect of unconventional policy has been the move of central banks to aggressively

purchase longer-term government securities along with expanding the size of its balance sheet. In this paper, I construct a rigorous modeling framework to investigate the impact of such policies. The inclusion of long-term assets and an independent central bank allows us to focus on a Treasury bond purchase program as a monetary policy tool. Outright open market operations through purchases of short-term government securities unambiguously lower yields and promote economic activity. By comparison, long-term asset purchases are only effective if short-term yields are sufficiently low. Should central bankers in countries with high debt loads and high short-term interest rates implement a long-term asset purchase program, it will be ineffective as it would only encourage fiscal authorities to issue more debt. Moreover, I also explain how the transmission channels of monetary policy between unconventional and conventional policies have important consequences for risk-sharing in the economy.

In particular, I believe that the three period framework that I offer opens up an array of interesting issues to be addressed in future research. For example, the model could be used to study the term structure of lending and credit market behavior. In addition, given the additional period in the lifecycle of agents in our model, future work could study how the transmission channels of monetary policy depend on the demographic structure of an economy. Notably, the degree of liquidity risk across the lifecycle could have important implications for asset prices in the economy.

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CHAPTER 3
UNCONVENTIONAL MONETARY POLICY AND CREDIT MARKET ACTIVITY

3.1 Introduction

One of the major developments in monetary policy has been the use of the size of central bank's balance sheets as an instrument to stimulate economic activity. The use of this "unconventional" tool has come about after traditional policy instruments have been exhausted during periods of considerable economic stress. For instance, amid the last global recession in December 2008, the Federal Reserve decreased the target for its short-term policy rate, the Fed Funds Rate, to be between zero and 25 basis points: a policy that remains up to this day. In contrast, the total amount of assets held by the Fed has increased by more than 440%: from $0.93 trillion in September 2008 to $4.47 trillion in April 2015. Although in a differing magnitude, the Bank of England (BOE) has followed a similar expansionary trend with the Bank of Japan (BOJ) and the European Central Bank (ECB) more recently initiating plans to increase the aggressiveness of their expansionary balance sheet policies.[1]

The success of the Fed's balance sheet, or "quantitative easing" (QE) measures in terms of lowering long-term interest rates on treasury securities is backed by a substantial body of empirical research.[2] Similarly, but for the BOE's asset purchases, econometric findings like that in Joyce et al. (2011) find a reduction in medium to long- term government bond yields by about 100 basis points. In the case of Japan, Ueda (2012) and Takeda and Yajima (2014) find that the BOJ's QE program -initiated in March 2001- depressed long-term rates of Japanese government securities as well as of several privately-issued

[1]The BOJ announced on October 2014 an open-ended increase of $37 billion/month on its purchases of Japanese government bonds starting in 2015. On January 2015, the ECB announced an expansion of its asset purchase program from $14 billion/month to $68 billion/month until at least September 2016.

[2]See Meyer and Bonfim (2012), Li and Wei (2012) and Pandl (2012) for the cumulative effects of the Fed's QE programs including the Maturity Extension Program.

assets.

All of this empirical research supports the effectiveness of balance sheet programs mostly in financial markets. However, studies on the impact of these programs on bank lending are scant or relatively new.[3] The need for a deeper insight in this "banking channel" of monetary policy is brought up by Boivin, Kiley and Mishkin (2011), who correlate the reduced amount of theoretical studies in the area with the difficulty of finding and specifying the relevant mechanisms necessary to perform empirical analysis.

In this paper I contribute to this gap in the literature by providing a framework that illustrates how the size of a Central Bank's (CB) balance sheet impacts lending by banks in the credit market. Specifically, I offer a structure in which an independent monetary authority controls the rate of money growth and engages in the purchase of short-term and long-term bonds issued by a fiscal authority. In turn, these policies affect the investment decisions of financial intermediaries.

Given that the impact of monetary policy decisions on credit markets depends on the actions of financial intermediaries, our modeling approach seriously takes into account this feature by having an explicit role for these institutions. Namely, and as shown by Diamond and Dybvig (1983), intermediaries provide crucial risk-sharing services that insure agents against liquidity risk. Additionally, intermediaries provide intertemporal consumption-smoothing services by issuing loans in credit markets. Financial intermediation is also relevant for monetary policy since it avoids socially undesirable levels of short-term, liquid-asset investments and thus favoring longer-term investment allocations in the spirit of Bencivenga and Smith (1991). These features allow us to model in an explicit manner how monetary policy affects the incentives of banks to issue long-term private debt and hold long-term government securities. I also offer a well-defined role for money as means of exchange in order to rigorously analyze the rate of money growth as a policy instrument.

Our modeling framework presents an overlapping generations structure that rests on Schreft & Smith (1997) in which financial intermediaries provide risk-pooling services to

[3]See Bowman et al. (2011) who find a positive effect of the BOJ's QE policies on Japanese bank's lending and Joyce and Spaltro (2014) who find similar effects of balance sheet policies in the UK.

depositors that are prone to random liquidity draws. Also, informational asymmetries generate a well-defined transactions role for money. These liquidity shocks represent consumption preference shocks as in Diamond and Dybvig (1983).

Our setup differs from Schreft & Smith (1997) and (1998), as I have an independent monetary authority that is separate from its fiscal counterpart. Additionally, I also depart from Schreft & Smith (2002) in that the monetary authority keeps part of its income such that any purchase of government debt originates an outstanding liability on the fiscal authority's balance sheet. That is, our setup analyzes true open market operations. I also build on the findings by Ghossoub, Laosuthi and Reed (2006) as well as Laosuthi and Reed (2012) in which they analyze the effects of conventional monetary policy on the availability of credit in the presence of government debt and with differing degrees of banking market concentration. However, our setup differs from theirs in important ways. Aside from our crucial feature of a separate and independent CB, I also deliver a richer maturity structure of government debt. Thus, I are able to incorporate and analyze "unconventional" tools like CB long-term government security purchases while also contrasting its effects relative to those of "conventional" monetary policy instruments such as purchases of short-term government securities.

Our results indicate that short-term bond purchases decrease the level of risk-sharing for depositors. Nonetheless, they are effective in reducing short and long-term yields of treasury securities as well as in promoting lending by intermediaries while at the same time reducing the cost of private credit. In contrast, when the CB purchases long-term treasuries, the impact on the overall cost of borrowing and lending activity is contingent on the level of short-term interest rates. Namely, long-term bond purchases promote loan supply and reduce the cost of raising funds for private and public agents only under a "low" short-term interest rate regime. Otherwise, if the CB implements a long-term bond purchase program, a contractionary effect on the credit market can take place due to either a crowding out effect of government debt or through a reduction in the ability of the fiscal authority to subsidize credit market activity.

Finally, the paper is organized as follows. Section 2 introduces a benchmark, two-

period model meant to analyze a general expansionary balance sheet policy. Section 3 introduces an extended, three-period model in which the CB can expand its balance sheet through short-term and long-term bonds. Section 4 analyzes the economy in the steady state. Section 5 presents the implications for monetary policy and section 6 concludes.

3.2 A Benchmark Two-Period Model

I begin the analysis by studying a benchmark, two-period model in which the monetary authority follows a money growth rule and manipulates the size of its balance sheet by purchasing bonds, all of the same maturity. The analysis of this simple structure allows us to describe the different roles of the fiscal and monetary authorities. Further, and since several features of this simple model remain in the extended version, this exposition will allow for a better grasp of the implications of unconventional monetary policy when I introduce the extended model in the following section.

Our modeling structure has a separate and independent CB. This fact sets us apart from Schreft & Smith (1997) and (1998) in which monetary and fiscal policy is conducted by the same entity. The same difference is also true when comparing our framework with Ghossoub, Laosuthi and Reed (2006) as well as that of Laosuthi and Reed (2012). Even though Schreft & Smith (2002) do have a separate monetary authority, it rebates all of its returns from government securities back to the fiscal authority. In our case, the monetary authority keeps a fraction of its net revenues and can thus reinvest proceeds from government debt returns. This is also implies that in our setup, bond purchases reflect true market operations as these transactions imply a net fiscal liability.

Finally, once I illustrate the structure of this model, I proceed to the next section by extending the life-cycle of agents to three-periods and including purchases of long-term bonds among the instruments of the monetary authority.

3.2.1 The Environment

Time is discrete, infinite and indexed by $t = 0, 1, 2...\infty$. There are two symmetrical but separate locations, each populated by a unit-mass continuum of agents. These individuals live for two periods and can be either "depositors" or "borrowers".

At the start of time t, young depositors are endowed with $y_0 > 0$ units of a homogeneous consumption good and realize consumption c_{t+1} when old with preferences $u(c_{t+1}) = ln(c_{t+1})$. Every period, young depositors have a probability $\pi \in (0, 1)$ of geographically moving from their original location to the alternate location that creates a subpopulation of "movers" and "nonmovers". In turn, borrowers are endowed with $y_1 > 0$ units of the consumption good when old but value consumption when young and when old according to $u(c_t, c_{t+1}) = ln(c_t) + \beta ln(c_{t+1})$, where $\beta \in (0, 1)$ is the discount factor. Unlike depositors, borrowers are not subject to relocation risk.

A perfectly competitive banking sector is represented by financial intermediaries that simultaneously provide services in two different markets. First, in a deposit market, intermediaries offer rates of return taking competing bank's actions as given. Moreover, returns on deposits are contingent on the relocation status of its clients, offering r_t^m per unit deposited if a mover and r_t^n if a nonmover. Second, in the credit market, intermediaries offer riskless loans l_t at an interest rate of R_t per unit of the consumption good borrowed.

Limited communication among banks between locations exclude the possibility of trading privately-issued liabilities. In contrast, fiat money is the only globally accepted asset which is dominated in rate of return by all other assets in the economy. These constraints generate a transactions role for money that relieves a trading friction for relocated agents as they must prematurely liquidate asset holdings to obtain cash and be able to consume in their new location. In this sense, relocation risk triggers a sudden demand for money balances or liquidity risk that is analogous to a preference shock as in Diamond and Dybvig (1983).

Financial intermediaries offer returns to movers that depend on the the size of the overall moving population as well as the return to money holdings. In doing so, they are effectively pooling income resources to insure against liquidity risk. Moreover, intermediaries participate in the credit market by supplying loans to borrowers that allow them to smooth their lifetime consumption. In this manner, banks act as financial intermediaries that provide risk insurance and consumption smoothing services in the economy.

There is a fiscal authority and an independent central bank (CB) in the economy. The fiscal authority generates income by issuing risk-free bonds in nominal amount B_t, with real value $b_t \equiv \frac{B_t}{P_t}$, where P_t is the unit price of the consumption good. The gross real return to government debt per unit of the consumption good borrowed at time t is R_t^b.

The CB conducts monetary policy using instruments. First, it regulates the nominal money supply M_t by controlling the rate of money growth $\sigma > 1$ following the rule $M_t = \sigma M_{t-1}$. In this manner, the CB can affect the return on real money balances $m_t \equiv \frac{M_t}{P_t}$ which depends on the relative price level $\frac{P_t}{P_{t+1}}$.

The second instrument allows the CB to directly make use of its balance sheet by engaging in a bond purchase program. Specifically, the CB purchases bonds from the fiscal authority in amount b_t^{CB} every period. Finally, the CB transfers a fraction $\lambda \in (0, 1)$ of its net income to the fiscal authority.

3.2.2 Timing of Actions

I now describe the sequence of actions of depositors and borrowers as illustrated in figure 3.1. At the beginning of period t, young depositors, receive an endowment of $y_0 > 0$ which they deposit in the bank. In turn, intermediaries (banks) invest these funds in bonds, money balances and offer loans in a credit market. Next, young borrowers take out loans in order to consume during their middle age. Then, the relocation shock is realized and due to the limited communication between banks and restrictions on asset portability, moving agents must cash out their deposit from the bank. At the end of this period, depositors who have to relocate do so and carry money balances. Now, in their old stage, borrowers receive an endowment of $y_1 > 0$ which they use to payoff loan debt and afterwards, nonmovers claim their realized return on deposits. Finally, movers exchange their cash holdings for the homogeneous good with banks and all old agents consume.

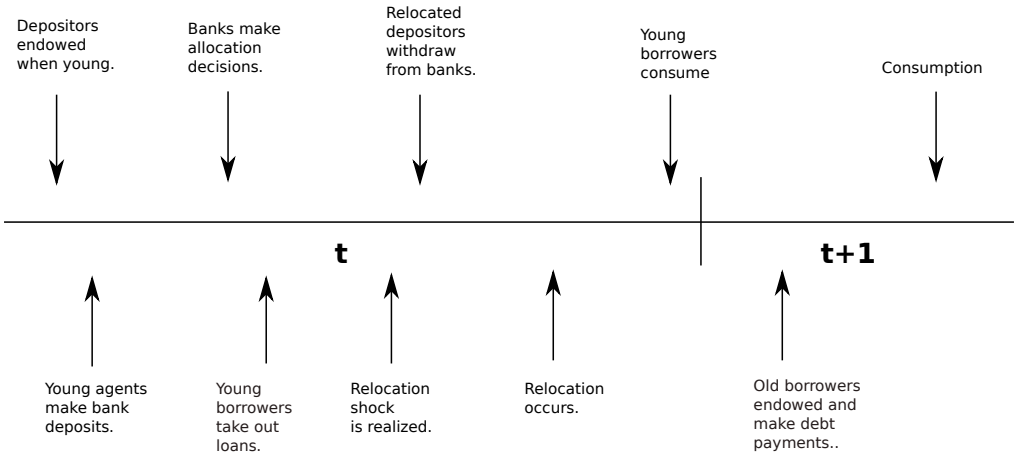

Figure 3.1: Benchmark model: depositors and borrowers' timing of actions.

3.2.3 Financial Intermediation

The Deposit Market

The market for financial intermediation is perfectly competitive and banks are identical across locations. Thus, a representative bank invests deposits into a portfolio of assets and announces returns of r_t^m for movers and of r_t^n for nonmovers. Hence, financial intermediation allows agents to have consumption levels of $c_t^m = r_t^m y_0$ if a mover, and $c_t^n = r_t^n y_0$ otherwise.

Interest rates on deposits depend on the bank's returns to investments in cash m_t, government bonds b_t^P, and loans l_t. Therefore, to guarantee that returns on deposits are feasible, the bank sets its cash holdings for movers such that:

$$\pi r_t^m y_0 \leq m_t \frac{P_t}{P_{t+1}} \tag{3.1}$$

and similary, but for the nonmovers, the bank will invest in bonds and loans offering returns that follow:

$$(1-\pi) r_t^n y_0 \leq R_t^b b_t^P + R_t l_t. \tag{3.2}$$

Furthermore, the bank's investment allocations are restricted by the amount of deposits in a balance sheet constraint:

$$y_0 \geq m_t + l_t + b_t^p. \tag{3.3}$$

It follows that in equilibrium, banks offer rates of return that maximize depositor's expected utility:

$$\max_{r_t^m; r_t^n} \left\{ \pi ln(r_t^m y_0) + (1-\pi) ln(r_t^n y_0) \right\}. \tag{3.4}$$

subject to (4.1)-(4.3).

The solution to the representative bank's problem implies that intermediaries hold money balances in an amount that is increasing in depositors' income and the degree of liquidity risk. This constitutes the optimal risk-sharing condition that permits banks to provide insurance against a random demand for liquidity in the form of cash:

$$m_t = \pi y_0. \tag{3.5}$$

Also from the bank's first order conditions, a no-arbitrage relationship holds:

$$R_t = R_t^b \tag{3.6}$$

which establishes that the cost of private debt has to equal that of public debt as banks exploit all profit opportunities in order to attract depositors.

The Credit Market

Borrowers are only endowed when old with y_1 units of the consumption good. The fact that they value consumption when young makes these individuals seek any consumption smoothing opportunities. Hence, these individuals will finance their consumption when young by taking out default-free loans in amount l_t^d at an interest rate of R_t in the credit market such that:

$$\max_{l_t^d} \left\{ ln(l_t^d) + \beta ln(y_1 - R_t l_t^d) \right\} \tag{3.7}$$

which gives a standard loan demand function that is increasing in income and decreasing in the cost of borrowing:

$$l_t^d = \frac{y_1}{(1+\beta)R_t}. \tag{3.8}$$

Finally, the market for loans clears so that:

$$l_t^s = l_t^d \tag{3.9}$$

for all $t \geq 0$.

3.2.4 The Central Bank

A monetary authority is represented by a CB that is responsible for the conduct of monetary policy. The CB has two instruments at its disposal. First, it controls the supply of money in the economy by altering the rate of money growth σ. This instrument provides the monetary authority with inflation tax proceeds or seigniorage revenue in amount $(\frac{\sigma-1}{\sigma})m_t$ every period. Second, the CB engages in a government security purchase program by acquiring bonds in amount b_t^{CB} and collecting returns on previously issued bonds in amount $R_{t-1}^b b_{t-1}^{CB}$. Thus, the CB resource constraint is depicted by:

$$R_{t-1}^b b_{t-1}^{CB} + \left(\frac{\sigma-1}{\sigma}\right) m_t - b_t^{CB} > 0 \tag{3.10}$$

where net income is strictly positive as the CB controls seigniorage revenue in order to avoid any losses. Finally, every period, the CB transfers a fraction $\lambda \in (0,1)$ of its net resources to the fiscal authority. These transfers allow monetary policy to influence the impact of public debt in the economy.

3.2.5 The Fiscal Authority

A fiscal authority issues debt in the form of bonds b_t every period, hence, government revenue comes from the sale of bonds to the CB and to private investors such that the bond market clears in every period:

$$b_t = b_t^{CB} + b_t^P, \tag{3.11}$$

for all $t \geq 0$.

Debt payments constitute the expense side of the fiscal authority's budget constraint in the LHS of (4.12). Additionally, its income is complemented every period by a fraction λ of the CB's net revenues so that under a balanced budget constraint:

$$R_{t-1}^b b_{t-1} = b_t + \lambda \left[R_{t-1}^b b_{t-1}^{CB} + \left(\frac{\sigma - 1}{\sigma} \right) m_t - b_t^{CB} \right] \tag{3.12}$$

3.2.6 Steady State Analysis

The steady state properties of the economy follow. First, by (4.6) and (4.8) I construct the no arbitrage locus:

$$l = \frac{y_1}{(1+\beta)R^b}, \tag{3.13}$$

which relates borrower's loan demand with the return on government debt.

Next, I obtain a second steady state relationship. Note that in a steady state equilibrium $P_{t+1}/P_t = \sigma$ so that using (3.5) and (4.11) into (4.12) yields:

$$b^P = \lambda \left(\frac{\sigma - 1}{\sigma} \right) \left(\frac{\pi y_0}{R^b - 1} \right) - (1 - \lambda) b^{CB} \tag{3.14}$$

This expression shows how private bond holdings are affected through monetary policy by way of open market operations given the net lending postion of the fiscal authority. For instance, when $R^b - 1 > 0$, net real interest rates are positive which implies that the fiscal authority is a net borrower: $b^p > 0$. In this case, CB bond purchases can reduce the amount of public debt in intermediaries portfolios and free up resources that can now be invested in other assets such as loans. Similarly, when $R^b - 1 < 0$, there are negative net real interest rates and the fiscal authority is a net lender: $b^P < 0$. This fact implies that the fiscal authority is in fact lending low cost resources to intermediaries which constitute a subsidy. Under this scenario, CB purchases of government bonds facilitate

fiscal subsidies which increase investment resources to intermediaries. Note that in both cases, the effectiveness of monetary policy increases as CB transfers λ decrease. This highlights the relevance of the CB's fiscal independence and thus the importance of a CB expansionary balance sheet policy to affect lending activity. To gain a deeper insight, I substitute the value of b^p in (4.14) into the bank's balance sheet constraint described by (4.3), and obtain an expression for the steady state loan supply level:

$$l = y_0 - \pi y_0 \left[1 + \frac{\lambda \left(\frac{\sigma - 1}{\sigma} \right)}{R^b - 1} \right] + (1 - \lambda) b^{CB}. \tag{3.15}$$

This expression denotes important aspects of credit intermediation. For instance, increases in cash reserves due to higher liquidity shocks reduce the supply of credit. Also, higher borrowing costs reflected by R^b, positively impact loan supply. Furthermore, CB bond purchases can effectively increase loan supply by reducing the supply of government debt available so that intermediaries destine more resources to loan investment. Next, I offer conditions for a steady-state to exist.

Proposition 1. *(Existence of Multiple Steady States). Assume (4.10) holds and let* $\hat{l} \equiv [1 - \pi(1 - \lambda)]y_0 + (1 - \lambda)b^{CB}$. *Further, assume that borrower's endowments when old are such that:*

$$y_1 > \left[y_0 + (1 - \lambda) \left(b^{CB} - \pi y_0 \right) \right] \left(\frac{1 + \beta}{\sigma} \right).$$

Under these conditions, multiple steady states exist in which the net fiscal position of the fiscal authority as well as credit market activity differ. In one economy there is low credit market activity and the fiscal authority is a net borrower; in the other, higher credit market activity coexists with a fiscal authority that is a net lender.

Figure 3.2.6 illustrates the two steady-state equilibria. The economy in A in which the fiscal authority is a net borrower, the existing levels of public debt result in a highly distorted credit market. This condition is illustrated by economy A having low levels of lending activity along with high borrowing costs. In contrast, the economy in B in which the fiscal authority is a net lender, there exist more efficient credit markets with

comparatively low interest rates and higher lending volume.

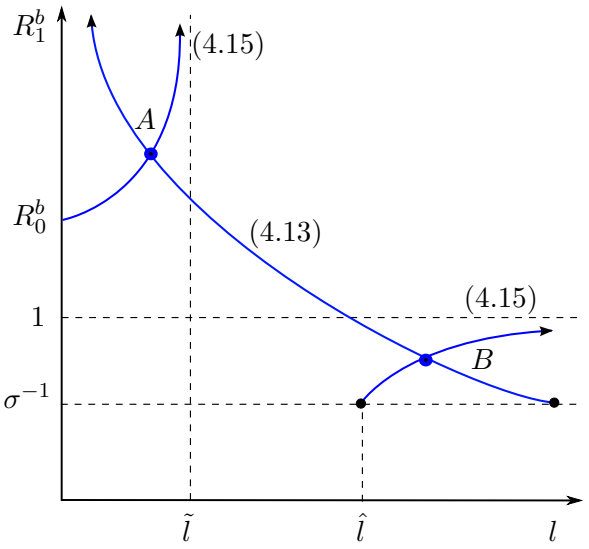

Figure 3.2: Benchmark model: steady state equilibria.

3.2.7 Comparative Statics

Rate of Money Growth Rule

Next, I study the effects of monetary policy in the steady state. Starting with money supply in the economy, the impact of an increase in the rate of money growth is summarized by the following proposition:

***Proposition* 2.** *(Increase in the Rate of Money Growth).*

i. When the overall stance of the fiscal authority is of a net debtor: $\frac{dl}{d\sigma} < 0$, $\frac{dR^b}{d\sigma} > 0$, $\frac{dR}{d\sigma} > 0$.

ii. When the overall stance of the fiscal authority is of a net lender: $\frac{dl}{d\sigma} > 0$, $\frac{dR^b}{d\sigma} < 0$, $\frac{dR}{d\sigma} < 0$.

Figure 3.2.7 describes these effects. Higher rates of money growth increase resources transferred to the fiscal authority. In the economy with low levels of credit market activity, the fiscal authority utilizes these additional resources to issue more debt. However, in order for the bond market to clear according to (4.11), the return to bonds has to increase. The final outcome is a reduction in credit activity as higher returns for public debt crowd out loan investment from intermediaries' portfolios. In contrast, in the economy with comparatively larger credit market activity, higher seigniorage transfers allow the fiscal

authority to enhance resource subsidies to the private sector. In turn, these intermediaries allocate more resources to loan investment that by (3.9) reduces the cost of private borrowing increasing lending volume.

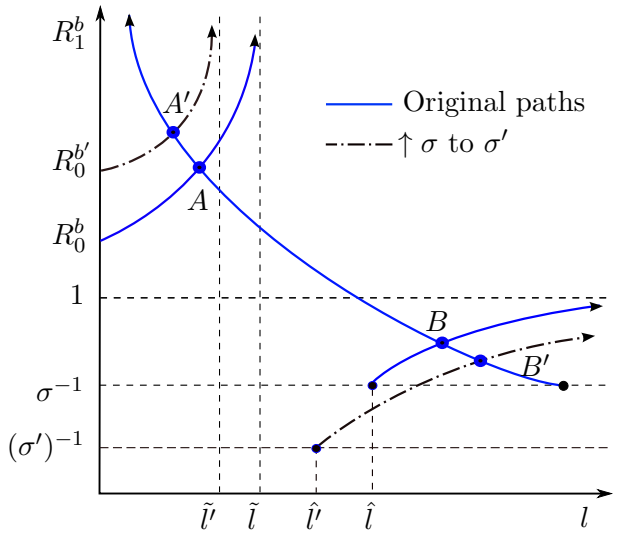

Figure 3.3: Benchmark model: money growth policy.

Bond Purchase Program

In contrast with a money growth policy, the impact of an expansionary balance sheet policy through purchases of government securities differs as illustrated by the following proposition:

Proposition 3. *(Treasury Purchases). Irrespective of the fiscal authority's net lending position,* $\frac{dl}{db^{CB}} > 0$, $\frac{dR^b}{db^{CB}} < 0$, $\frac{dR}{db^{CB}} < 0$.

As can be seen in figure 3.2.7, in both cases expansionary balance sheet policy increases the asset side of the fiscal authority via transfers. At the same time, because the central bank keeps a fraction $1 - \lambda$ of bond purchases, fiscal liabilities also increase.

However, when the fiscal authority is a net borrower, bond purchases by the monetary authority also reduce intermediaries' investment opportunities in public debt. In this case, the ultimate outcome is a decline in bond supply which shifts intermediaries resources toward loan investment. For the loan market to clear, the cost of private and public borrowing must go down by condition (3.9).

If the fiscal authority is a net lender, through this policy, the monetary authority is

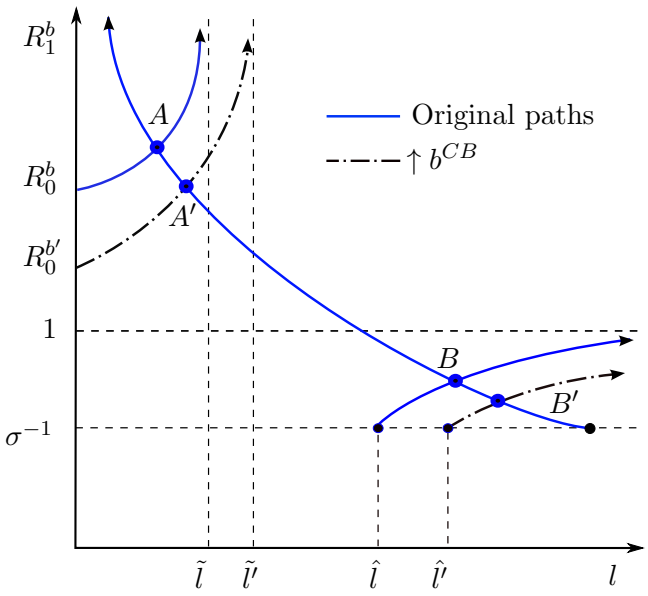

Figure 3.4: Benchmark model: short-term bond purchases.

effectively lending low cost resources to the fiscal authority. In turn, this enhances subsidies to the private sector which allows these intermediaries to allocate greater resources into loan investments. As a result the cost of borrowing declines by loan market clearing.

3.3 A Three-Period Model

I now build on the previous benchmark model by extending the life-cycle of agents as well as the maturity structure of assets in the economy. The objective of this setup is to enrich the set of monetary policy instruments by including purchases of long-term government securities. In this manner, the monetary authority can now implement an expansionary balance sheet policy by purchasing bond securities of short and long-term maturities in order to affect credit market activity.

3.3.1 The Environment

In the population of size one, individuals live for three periods denoted by "young", "middle aged" and "old". When young, depositors are endowed with $y_0 > 0$ units of the homogeneous consumption good and the relocation shock occurs during their middle age. These agents value consumption only when old. Borrowers are endowed with $y_1 > 0$ units of the consumption good when old and value consumption opportunities when middle aged and when old.

The fiscal authority issues debt obligations with different maturity structures. For instance, it issues short-term (one-period) bonds whose real value I denote by $b_{1,t}$. A holder of a unit of this security at time has the right to a claim of $R^b_{1,t}$ units of the consumption good borrowed at time $t-1$. The fiscal authority also issues long-term bonds $b_{2,t}$ which give a return of $R^b_{2,t}$ for every unit of the consumption good borrowed two periods before, or at $t-2$.

Therefore, along with controlling the rate of money growth and short-term bond purchases $b^{CB}_{1,t}$, the CB now uses its balance sheet as a third instrument by engaging in long-term bond purchases in amount $b^{CB}_{2,t}$ every period.

3.3.2 Timing of Actions

I now describe the sequence of actions of depositors and borrowers in the economy by following figure 3.5. At their young stage, depositors receive an endowment which they deposit in the bank. With these resources, intermediaries conform investment portfolios on behalf of their depositors. Afterwards, borrowers take out loans to finance middle-age consumption. When the middle stage arrives, the relocation shock is realized and a fraction π of young depositors will terminate their investments early. These middle aged movers exchange thier investment returns for cash held by old movers that arrived from the opposite location and are in need to consume in this stage. Once middle-aged movers relocate, they become old and exchange their cash holdings for the consumption good with the middle-aged movers from their new location. At the same time, borrowers receive their endowment which they consume after honoring loan payments.

3.3.3 Financial Intermediation

The Deposit Market

In contrast to the benchmark model, banks do not invest in cash. The fact that the relocation shock takes place after a depositor's young period allows banks to invest in a higher-yield asset on their behalf -in this case a one period, or short-term bond- that matures before relocation takes place. Consequently, movers must obtain cash outside the banking system. They do so by exchanging their deposit returns for cash with now

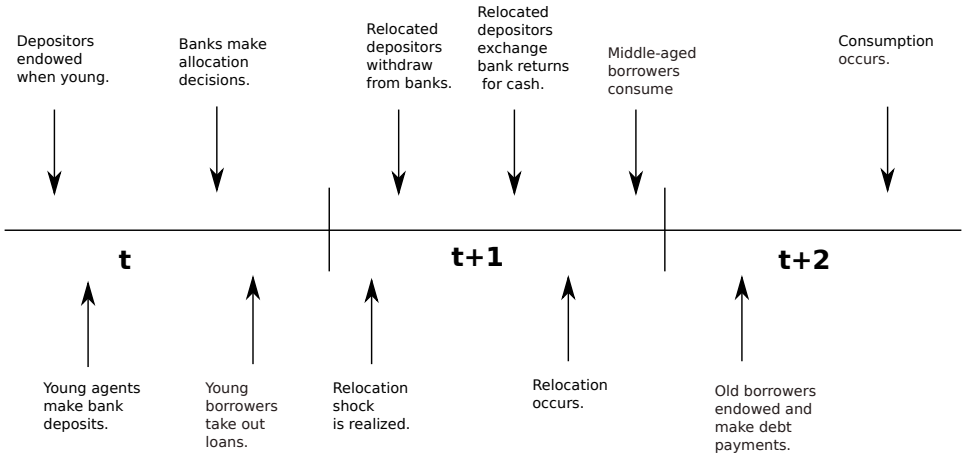

Figure 3.5: Depositors and borrowers' timing of actions.

old movers that arrived from the opposite location.

It follows that bank returns depend on the yield of short-term bond investments for movers $b^m_{1,t}$ and for nonmovers $b^n_{1,t}$, as well as of long-term bond purchases $b^n_{2,t}$. Additionally, bank returns are complemented by returns to private debt investment in the form of loans l_t. The rate of return to loans constitutes a sure claim of R_t per unit of the consumption good borrowed in $t-2$ making private borrowing a long-term liability. Given returns on deposits of r^m_t and r^n_t, deposit market participants have access to consumption levels of $c^m_t = r^m_t y_0$ if a mover and $c^n_t = r^n_t y_0$ otherwise.

Thus, on behalf of its moving depositors, the bank will invest in a short-term bond taking into account the return to money balances:

$$r^m_t y_0 \leq (R^b_{1,t+1} b^m_{1,t}) \frac{P_t}{P_{t+1}}. \tag{3.16}$$

Similarly, feasibility of bank returns to nonmovers yields:

$$r^n_t y_0 \leq (R^b_{1,t+1} b^n_{1,t}) R^b_{2,t+2} + R^b_{2,t+2} b^n_{2,t} + R_{t+2} l_t. \tag{3.17}$$

These constraints imply that the bank's balance sheet constraint is described by:

$$y_0 \geq b^m_{1,t} + b^n_{1,t} + b^n_{2,t} + l_t. \tag{3.18}$$

In a perfectly competitive deposit market, a representative bank offers rates of return

that solve:

$$\max_{r_t^m; r_t^n} \{\pi ln(r_t^m y_0) + (1-\pi) ln(r_t^n y_0)\} \tag{3.19}$$

subject to (3.16)-(3.18).

The solution to the bank's problem determines the optimal risk-sharing condition reflected by the bank's purchases of short-term bonds for its moving clients:

$$b_{1,t}^m = \pi y_0, \tag{3.20}$$

which are proportional to the size of the deposit base as well as the magnitude of the relocation shock.

However, before changing locations, moving depositors will exchange their bank returns $R_{t+1}^b b_{1,t}^m$ for cash with the now old movers from the opposite location. Thus, and in line with (3.20), money demand is given by:

$$m_{t+1} = R_{1,t+1}^b (\pi y_0). \tag{3.21}$$

In addition, I obtain two no-arbitrage conditions between the rates of return of public versus private debt:

$$R_{1,t+1}^b R_{1,t+2}^b = R_{t+2} \tag{3.22}$$

$$R_{2,t+2}^b = R_{t+2}. \tag{3.23}$$

Expression (3.22) imposes the representative bank to invest until the compounded return on short term debt equals the long term return on private investment. The following expression (3.23) indicates the same action forcing the equality of returns of existing long-term investment opportunities. These two expressions imply that

$$R_{1,t+1}^b R_{1,t+2}^b = R_{2,t+2}^b \tag{3.24}$$

which lays the term structure of interest rates in the economy.

The Credit Market

Borrowers will take out default-free loans l_t^d in the credit market at an interest rate of R_{t+2}. At optimality, borrowers take out loans such that:

$$l_t^d = \frac{y_1}{(1+\beta)R_{t+2}} \tag{3.25}$$

So that at a given income level and rate of time preference, demand for loans decreases with the cost of borrowing.

At every $t > 0$, the credit market clears:

$$l_t = l_t^d, \tag{3.26}$$

for all $t \geq 0$.

3.3.4 The Central Bank

The monetary authority conducts open market operations and obtains seigniorage revenue by controlling the rate of money growth. In this setup however, by purchasing long term bonds $b_{2,t}^{CB}$ the monetary authority has an additional mean to use its balance sheet and affect credit market activity. Thus, re CB's resource constraint is depicted by:

$$R_{1,t-1}^b b_{1,t-1}^{CB} + R_{2,t-2}^b b_{2,t-2}^{CB} + \left(\frac{\sigma - 1}{\sigma}\right) m_t - b_{1,t}^{CB} - b_{2,t}^{CB} > 0 \tag{3.27}$$

3.3.5 The Fiscal Authority

Every period the fiscal authority issues short and long term bonds to finance its previous debt payments. Both types of securities are purchased by intermediaries in their effort to provide risk-sharing and consumption-smoothing services, as well as by the central bank to conduct expansionary balance sheet policies. Short term bond securities mature within one period and at any point in time the market for these securities clears:

$$b_{1,t} = b_{1,t}^m + b_{1,t}^n + b_{1,t}^{CB}, \tag{3.28}$$

for all $t \geq 0$.

Long-term bonds mature within two periods and similarly:

$$b_{2,t} = b^n_{2,t} + b^{CB}_{2.t}, \tag{3.29}$$

for all $t \geq 0$.

Along with debt revenue, the fiscal authority makes use of income transfers from the monetary authority. These transfers consist of a fraction λ of net proceeds as depicted in (3.27) and it is another revenue source destined to honor debt obligations. Consequently, the fiscal authority's budget constraint is represented by :

$$R^b_{1,t-1}b_{1,t-1} + R^b_{2,t-2}b_{2,t-2} = b_{1,t} + b_{2,t} + \lambda\left[R^b_{1,t-1}b^{CB}_{1,t-1} + R^b_{2,t-2}b^{CB}_{2,t-2} + \left(\frac{\sigma-1}{\sigma}\right)m_t - b^{CB}_{1,t} - b^{CB}_{2,t}\right] \tag{3.30}$$

In this manner, the rate of money growth as well as government debt purchases by the monetary authority can influence the supply of public debt in the economy.

3.4 Steady State Analysis

I start by studying the role of bond purchases by the monetary authority. Looking at the bank's balance sheet constraint in (4.3) and plugging in for the risk-sharing condition in (3.20), we have that:

$$l = y_0(1-\pi) - (b^n_{1,t} + b^n_{2,t}) \tag{3.31}$$

This expression illustrates two important facts about loan intermediation. First, for a given depositor income level, an increase in the frequency of liquidity shocks compromises resources for long term loan investment. Secondly, increased borrowing by the fiscal authority can potentially reduce the amount of loans that intermediaries supply in the credit market. That is, public debt can "crowd out" private loan investment in detriment

of the ability of intermediaries to provide consumption-smoothing services.

However, in this intermediation process there is a non-trivial role for monetary policy. To see this, first note that in the steady state, $(R_1^b)^2 = R_2^b$ by (3.24). Hence, I can rewrite (3.30) by making use of (3.20) along with (3.28) and (3.29) so that:

$$b_1^n + (R_1^b + 1)b_2^n = \pi y_0 \left[\lambda \left(\frac{\sigma - 1}{\sigma}\right)\left(\frac{R_1^b}{R_1^b - 1}\right) - 1\right] - (1 - \lambda)\left[b_1^{CB} + (R_1^b + 1)b_2^{CB}\right] \quad (3.32)$$

This expression implies that bond purchases by the monetary authority have a direct impact on the amount of government securities available to private investors. I discuss the two possible cases based on the fiscal authority's net lending position.

In the case for which $R_1^b - 1 > 0$, the fiscal authority is a net borrower as long as $\lambda\left(\frac{\sigma-1}{\sigma}\right)\left(\frac{R_1^b}{R_1^b-1}\right) - 1 > 0$ or equivalently:

$$\lambda \left(\frac{\sigma - 1}{\sigma}\right) R_1^b > R_1^b - 1. \quad (3.33)$$

This inequality implies that the real value of seigniorage resource transfers must be greater than the net real debt obligations of the fiscal authority. I assume this restriction holds so that an increase in bond purchases by the monetary authority reduces the supply of bonds that otherwise would be allocated into intermediaries' portfolios. Looking back at (3.31) suggests that bond purchases reduce fiscal debt distortions in the credit markets by allowing intermediaries to invest a greater amount of deposits into loans.

When $R_1^b - 1 < 0$, the fiscal authority is a net lender to the private sector. In this respect, bond purchases by the monetary authority increase the resource capacity of the fiscal authority. In turn, by (3.31), intermediaries can destine more resources into loan investment.

I now focus on the existence of steady state equilibrium in the economy. Using (3.31) and (3.32) I obtain the steady state loan supply in the economy:

$$l = y_0 \left\{ 1 - \pi\lambda \left(\frac{\sigma - 1}{\sigma} \right) \left[\frac{R_1^b}{R_1^b - 1} \right] \right\} + (1-\lambda) b_1^{CB} + \left[1 - \lambda(R_1^b + 1) \right] b_2^{CB} + R_1^b b_2. \quad (3.34)$$

This expression indicates the partial marginal impact of bond purchases on credit availability. Specifically, short-term bond purchases always increase loan investment since $1 - \lambda > 0$ while the effect of long-term bond purchases $1 - \lambda(R_1^b + 1)$ also depends on the level of short-term interest rates.

Similarly, I derive the second steady-state condition which is the no-arbitrage locus between the returns to private and public borrowing. Taking (3.24), I use the fact that $\left(R_1^b\right)^2 = R$ holds by (3.22) so that:

$$l = \frac{y_1}{(1+\beta)(R_1^b)^2}. \quad (3.35)$$

Equations (3.34) and (3.35) capture the steady-state behavior of the economy.

Proposition 4 *(Existence of Multiple Steady States): Assume (3.27) holds and let* $\hat{l} = \left[y_0(\lambda\pi + \sigma) + b_2 - \lambda b_2^{CB} \right] \sigma^{-1} + (1-\lambda)(b_1^{CB} + b_2^{CB})$. *Moreover, assume that borrower's endowments are such that:*

$$y_1 > \left[y_0(\lambda\pi + \sigma) + b_2 - \lambda b_2^{CB} + (1-\lambda)(b_1^{CB} + b_2^{CB})\sigma \right] (1+\beta)\sigma^{-3}.$$

Then, under these conditions, two steady states exist. In one, the fiscal authority is a net borrower yielding low credit market activity, while in a second one, the fiscal authority is a net lender allowing for high levels of credit market activity.

The steady state equilibria is depicted in figure 3.4. I now turn to the analysis of the effects of monetary policy.

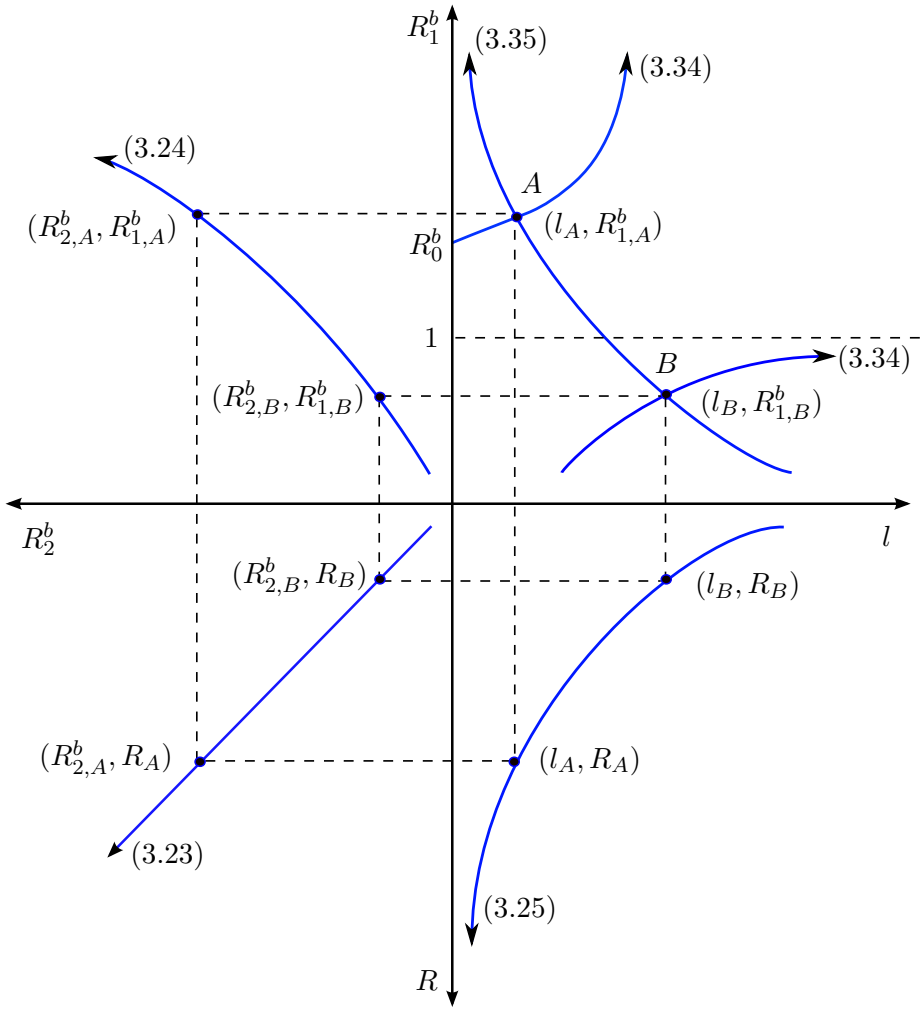

Figure 3.6: Steady state equilibria.

3.5 Comparative Statics

Rate of Money Growth

Proposition 5. *(Increase in the Rate of Money Growth).*

i. In economies in which the fiscal authority is a net borrower: $\frac{dl}{d\sigma} < 0$, $\frac{dR_1^b}{d\sigma} > 0$, $\frac{dR_2^b}{d\sigma} > 0$, *and* $\frac{dR}{d\sigma} > 0$.

ii. In economies in which the fiscal authority holds a net lending position: $\frac{dl}{d\sigma} > 0$, $\frac{dR_1^b}{d\sigma} < 0$, $\frac{dR_2^b}{d\sigma} < 0$ *and* $\frac{dR}{d\sigma} < 0$.

Figure 3.5 depicts the effects of an increase in the rate of growth of money. Higher rates of money growth increase seigniorage transfers to the fiscal authority. In the economy with low credit activity, this policy allows the fiscal authority to issue more debt. Due to (3.28) and (3.29) higher bond payouts take place. Moreover, higher returns on public

debt crowd out loan investment from intermediaries portfolios. Through the no arbitrage conditions (3.22) and (3.23) there is an increase in the overall cost of borrowing which is ultimately reflected by a decline in lending volume.

In the economy with high credit activity, this policy allows the fiscal authority to increase low-cost lending to the private sector . These additional resources boost loan investment by intermediaries thereby reducing the cost of private borrowing so that (3.26) holds. In turn, no arbitrage conditions from the bank's problem guarantee a reduction in the cost of public borrowing.

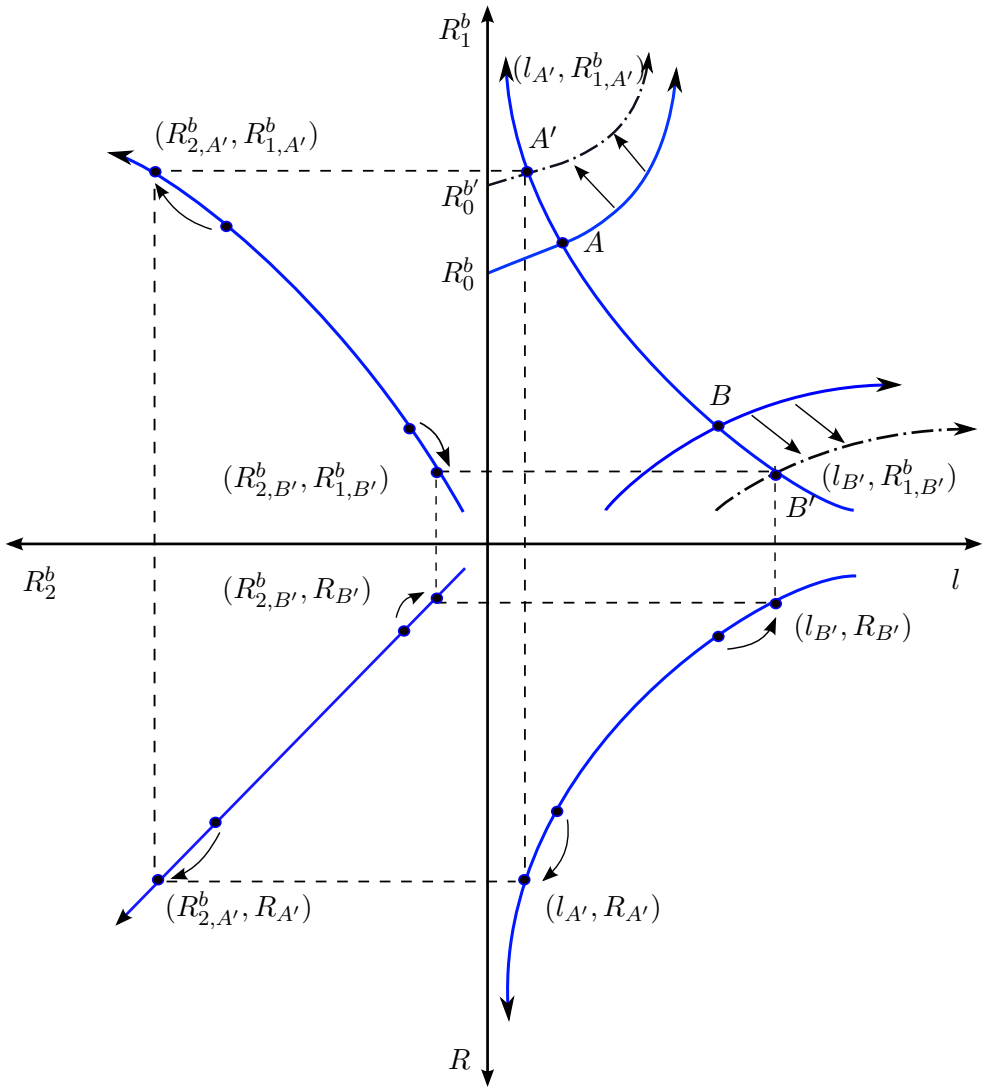

Figure 3.7: Money growth policy.

Open Market Operations

Proposition 6. *Irrespectively of the fiscal authority's net lending stance,* $\frac{dl}{db_1^{CB}} > 0$, $\frac{dR_1^b}{db_1^{CB}} < 0$, $\frac{dR_2^b}{db_1^{CB}} < 0$ *and* $\frac{dR}{db_1^{CB}} < 0$.

Purchases of short-term bonds by the monetary authority increase credit market activity and reduce borrowing costs irrespective of the fiscal authority's financial position as shown in figure 3.5. In the steady state with low credit market activity, short-term bond purchases reduce the availability of public-debt investment opportunities for intermediaries. Consequently, more resources are directed towards loan investments which reduce the equilibrium interest rate on loans.

In the steady state where the fiscal authority is a net lender, the monetary authority is transferring as well as effectively lending low cost resources to the fiscal authority. Open market operations then increase supplemental income to the fiscal authority that puts downward pressure on the cost of short-term public borrowing. At the same time, through increased loans from the monetary authority, the fiscal authority augments subsidies to the private sector causing an increase in resources directed at loan investment. Therefore, the private cost of borrowing must decline in equilibrium. Finally, through the no arbitrage conditions the overall cost of borrowing in the economy declines.

Long-Term Bonds

When the monetary authority engages in a long-term bond purchase program, the impact on credit market activity differs relative to conventional open market operations. Namely, long-term bond purchases increase credit market activity and reduce the cost of public borrowing if:

$$R_1^b < \frac{1-\lambda}{\lambda} \equiv R_1^{b*}. \tag{3.36}$$

This condition implies that for long-term bond purchases to work, short-term interest rates must be "low". Such condition holds irrespectively of the net fiscal position of the government. In the economy with a highly distorted credit market, long-term bond

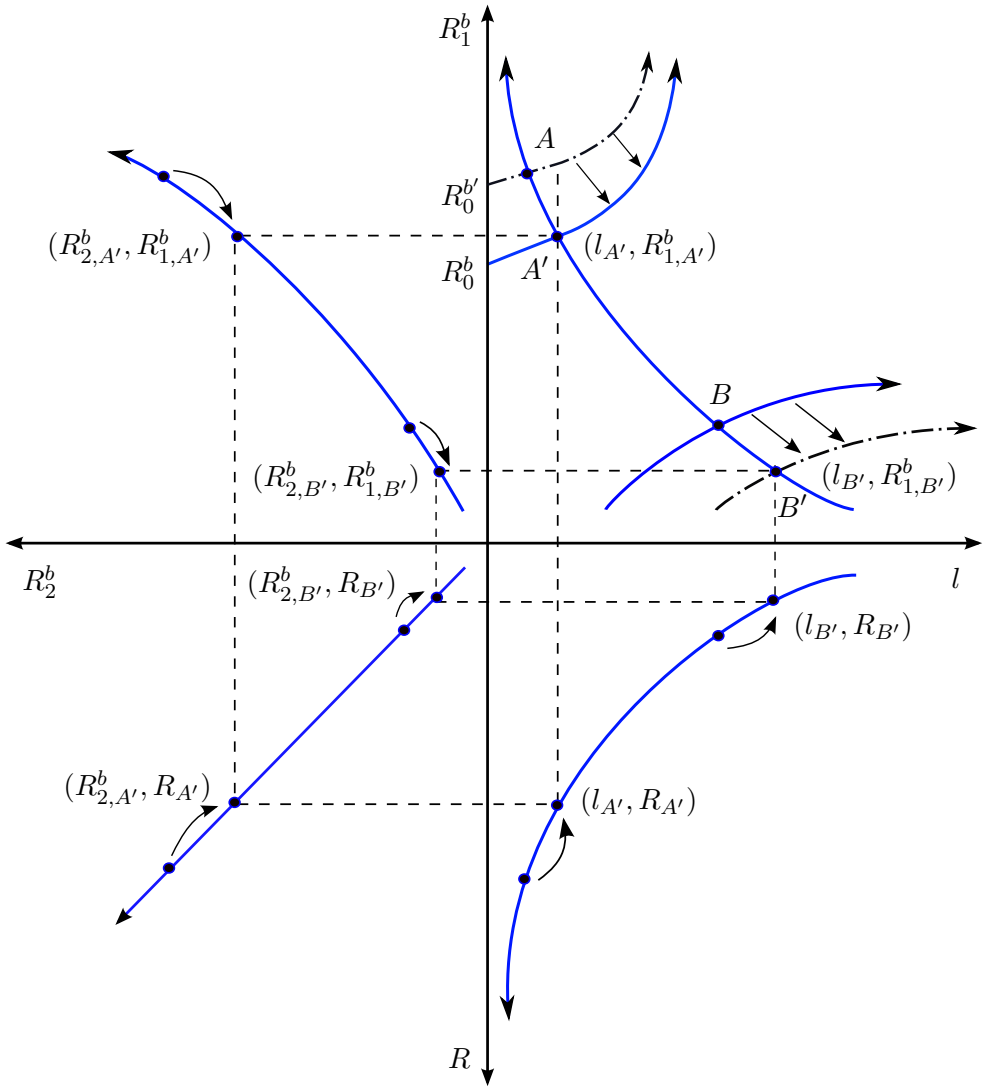

Figure 3.8: Effects of short-term bond purchases.

purchases are successful in withdrawing public debt from intermediaries' portfolios and stimulating loan investment. This effect dominates the increase in compounded resources -that translate into higher public debt levels- to the fiscal authority precisely because short-term interest rates are low in the sense of (3.36). Credit market clearing jointly with no-arbitrage conditions assure that overall interest rates across maturities decline. In the economy with high credit market activity, the monetary authority is effectively lending low cost resources to the fiscal authority. If again, interest rates are low enough, the compounded cost of servicing such debt is not high enough to compromise subsidies to the private sector. As a result, intermediaries have additional resources that increase loan supply and thus better servr the consumption-smoothing needs of borrowers.

Proposition 7. *Irrespective of the fiscal authority's net lending stance,* $\frac{dl}{db_2^{CB}} > 0$, $\frac{dR_1^b}{db_2^{CB}} < 0$, $\frac{dR_2^b}{db_2^{CB}} < 0$ *and* $\frac{dR}{db_2^{CB}} < 0$ *if short-term interest rates are such that condition (3.36) holds.*

Figure 3.5 shows the relevance of (3.36) for long term bond purchases to work. The interest rate level of economy A is higher relative to the threshold value of R_t^{b*} . Then, purchases of long term bonds by the CB ultimately crowd out loan investment while at the same time increasing the overall cost of borrowing public and private debt in the economy. This is reflected by the economy moving to the new steady-state A'.

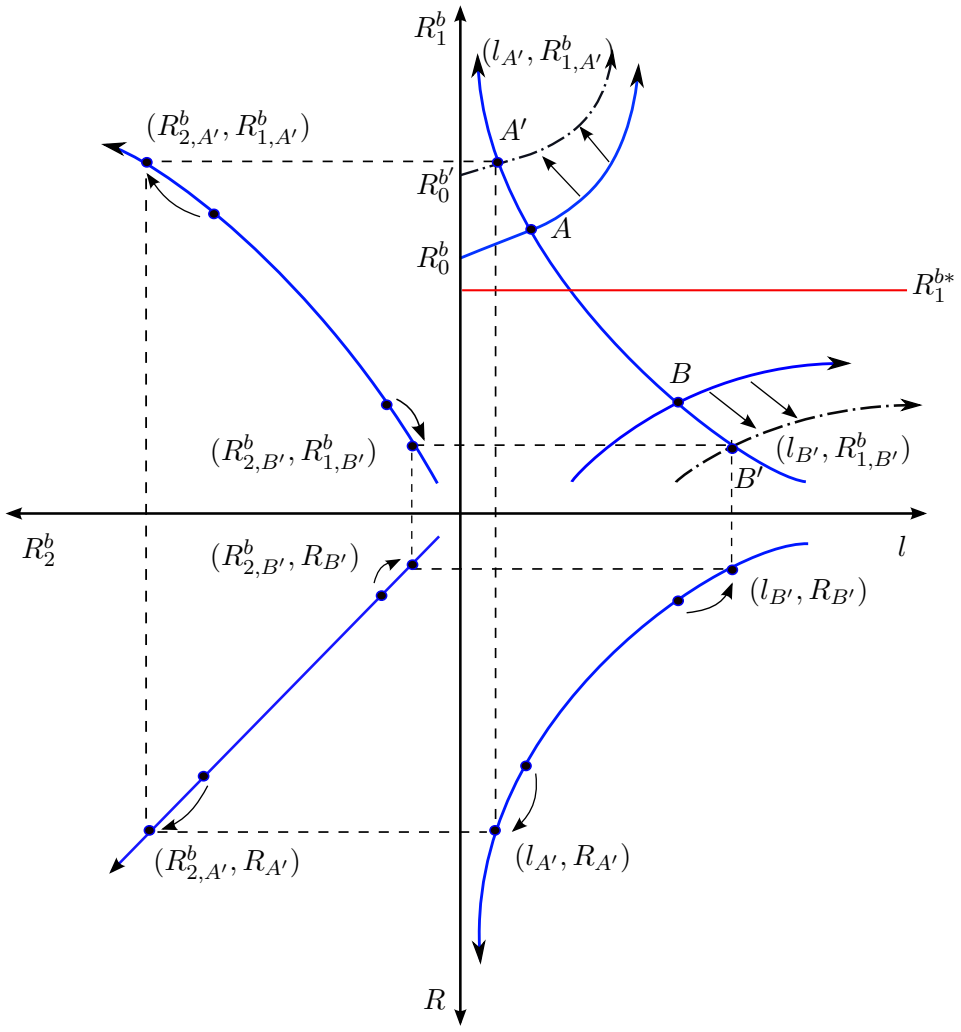

Figure 3.9: Long-term bond purchases: differential impact.

Similarly, figure 3.5 shows the ineffectiveness of this policy as both economies' interest rate levels violate condition (3.36).

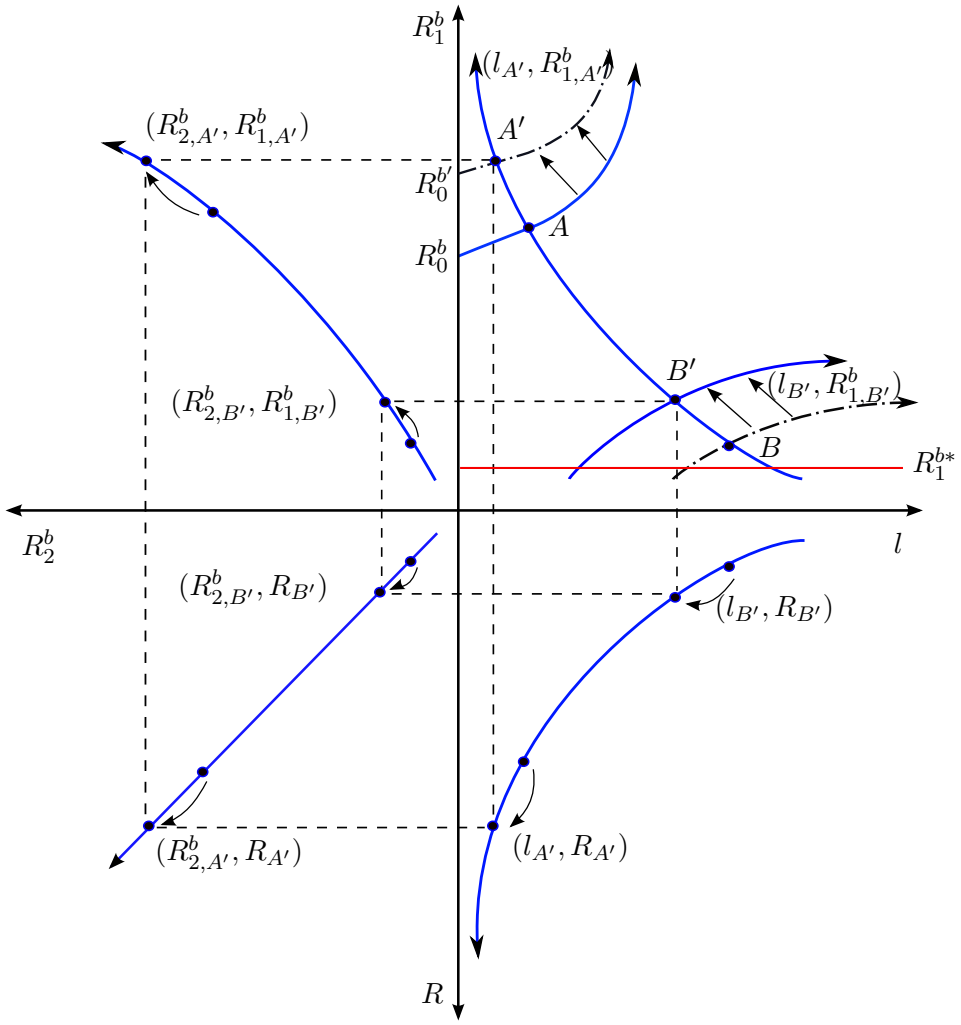

Figure 3.10: Long-term bond purchases: negative impact.

3.6 Conclusions

Recently, central banks around the world resorted to nontraditional policy tools to stimulate economic activity. A distinctive example was the expansion of the size of their balance sheets through the purchase of long-term government securities. In this paper I analyze the effect on credit markets of this "unconventional" monetary policy tool and compare it with that of conventional instruments such as open market operations. Our framework takes into account the role of financial intermediaries that provide risk-sharing and intertemporal consumption-smoothing services in the transmission mechanism of monetary policy. Our findings suggest that central bank purchases of long-term government securities stimulate credit market activity and reduce the cost of public and private borrowing only under a low interest rate and reduced fiscal debt regime. Otherwise, this

policy increases the cost of servicing debt resulting in a contraction of lending. In contrast, open market operations aid credit availability but negatively affect the amount of risk-sharing in the economy.

Our analysis suggest the need for future research to explore more about how unconventional monetary policy affects credit markets and other aspects of economic activity. This paper provides a rigorous framework from which one can further develop structures in order to explore other questions. For instance, the effect of monetary policy under a concentrated banking sector is of great importance. In an open-economy setting, the spillover effects of expansionary balance sheet policies are of interest for international central bank coordination as well as their impact on credit for emerging economies.

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CHAPTER 4
UNCONVENTIONAL MONETARY POLICY, CREDIT MARKET ACTIVITY AND FINANCIAL SECTOR COMPETITION

4.1 Introduction

The recent financial crisis brought the industrial organization of the banking sector to center stage. In the case of the U.S., the increasing market concentration among a few banking institutions has been a trend boosted by the recent financial turmoil. For example, Adams (2012) highlights that in the U.S. in 1980, around 19,069 banks existed whereas in 2010 this number declined by more than half to 7,011 institutions. Similarly, the 10 biggest banks managed around 13.5% assets in the financial system, whereas in 2010, this proportion increased to almost 50%. The situation has not improved, as recently Schaefer (2014) points out, as of December 2014 only five banks in the U.S. control 44% of the industry's $15 trillion in assets. Although in a differing degree, this market concentration process presents similar patterns in the European Union and the United Kingdom.

At the same time, in recent years central banks around the world turned to the use of the size of their balance sheets to stimulate lending in credit markets via purchases of long-term government debt. In the U. S., for example, the Federal Reserve increased the size of its balance sheet more than fourfold: total assets increased from $0.92 trillion in August 2008 to $4.3 trillion in May 2014.[1] Similarly aggressive balance sheet policies have been pursued by the Bank of England, European Central Bank and the Bank of Japan. [2]

These changes, both in the market structure of the banking system as well as in the

[1] `www.federalreserve.gov/monetarypolicy/bstrecenttrends.htm`

[2] See Meyer and Bonfim (2012), Li and Wei (2012) and Pandl (2012) for the cumulative effects of the Fed's QE programs; Bowman et al. (2011) find a positive effect of the Bank of Japan's QE policies on bank lending and Joyce and Spaltro (2014) who find similar effects of balance sheet policies in the UK.

tools of central banks pose several challenges for monetary policy. For instance, Bech et. al. (2014) find that the transmission mechanism of monetary policy is considerably impaired especially during episodes of economic decline associated with financial crises. This fact partially explains why central banks resorted to unconventional measures. Moreover, Boivin, Kiley and Mishkin (2011) highlight the need for further studies related to the "banking channel" of monetary policy, given the current lack of solid guidelines to empirically specify potential transmission channels.

In this way, it is pertinent to ask then, how does unconventional monetary policy impact credit market activity under different banking sector concentrations? How does it differ from the transmission mechanism of conventional monetary policy?

In this analysis, I provide answers to these questions by offering a framework that takes into account important aspects when modeling monetary policy. First, I have a well defined role for financial intermediaries. As these institutions provide services that individuals cannot achieve on their own, they perform fundamental roles in the economy. Second, money is established as a medium of exchange that alleviates a trading frictions in the face of imperfect information. Third, an independent monetary authority controls the rate of money growth and engages in government bond purchases. In turn, monetary policy impacts the credit market through financial intermediaries' investment allocations.

Given that the transmission mechanism of monetary policy depends on the actions of intermediaries, it is essential to have a well-defined role for banks. Particularly, this is essential in order to be able to understand how changes in banking market concentration modify the incentives of intermediaries to hold public and private debt liabilities. Consequently, our approach allows us to rigorously evaluate and identify what parts of the transmission mechanism of monetary policy are distorted when the CB attempts to stimulate credit market activity.

In this spirit I present an overlapping generations structure and follow Diamond and Dybvig (1983), in which financial intermediaries provide risk-pooling services that allow individuals to insure against liquidity risk. Furthermore, banking institutions also provide intertemporal consumption-smoothing services by channeling deposit funds towards loans

in a credit market. Similar to Schreft & Smith (1997, 1998), limited communication and restrictions to asset portability generate a transactions role for monetary exchange.

However, our approach differs from Schreft & Smith (1997, 1998), in that the monetary authority and the fiscal authority are separate entities. Along similar lines, in our model the monetary authority rebates back only a fraction of the fiscal authority's debt expenses. Such characteristic, aside from also setting us apart from Schreft & Smith (2002), allows us to talk about true open market operations. Our work contributes to the findings by Ghossoub, Laosuthi and Reed (2006) and Laosuthi and Reed (2012) in which they analyze the effects of conventional monetary policy on the availability of credit with imperfectly competitive intermediaries and in the presence of government debt. Nonetheless, our framework differs from theirs in that the monetary authority is a separate and fiscally-independent entity that conducts true open market operations. This feature is essential for the analysis of CB expansionary balance sheet policy.

Our findings confirm the distortionary effects of banking concentration in the transmission of monetary policy. Under perfectly competitive intermediation and in economies with low levels of public debt, an increase in the rate of money growth decreases interest rates and increases loan volume. This can also be the case in economies with high public debt levels only if the asset substitution effect on intermediaries portfolios outweighs the crowding out effect of increased government debt. Similarly under the same competitive banking sector but independently of the public debt load of the economy, CB bond purchases stimulate credit market activity by reducing interest rates and increasing loan availability.

In contrast, when the banking sector is fully concentrated, the impact of monetary policy on credit markets can be distorted. For instance, an increase in the rate of money growth fails to stimulate credit markets when the economy is subject to "high" liquidity shocks and if nominal interest rates are low. On the other hand, CB bond purchases reduce interest rates and increase loan amounts as in the competitive banking case but the magnitude of the effect is lower under a fully concentrated banking sector if the economy has a low interest rate environment.

Finally, the paper is organized as follows. Section 2 introduces the environment with a perfectly competitive banking sector. Section 3 analyzes the economy in the steady state in which the CB follows a money growth rule and is able to expand its balance sheet through open market operations. Section 4 studies the implications on monetary policy when the banking sector is fully concentrated. Section 5 studies the steady state implications of monetary policy in the presence of a monopoly bank. Section 6 compares the effects of unconventional monetary policy under different concentrations in the market for intermediation and section 7 concludes.

4.2 The Environment

Time is discrete, lasts forever and indexed by $t = 1, 2, ...\infty$. The world consists of two separate but identical locations populated by of two types of agents denoted as "depositors" and "borrowers". Each type is of unit-mass size and depositors are ex-ante identical. All individuals live for two periods, denoted as "young" and "old".

Depositors born at time t are endowed with $y_0 > 0$ units of a homogeneous consumption good when young and none when old. They only value consumption in their old stage according to preferences $u(c_{t+1}) = \frac{c_{t+1}^{1-\theta}}{1-\theta}$, where $\theta < 1$ is the relative risk aversion coefficient. At any period, there is a probability $\pi \in (0, 1)$ that a young depositor will have to migrate to the other location. These individuals are denoted as "movers" and the remaining as "nonmovers". In contrast, borrowers are not prone to relocation risk and they are endowed exclusively when old with $y_1 > 0$ units of the consumption good. Further, borrowers value consumption when young c_t, and old c_{t+1}, as depicted by their lifetime utility $u(c_t, c_{t+1}) = \frac{c_t^{1-\theta}}{1-\theta} + \beta\frac{c_{t+1}^{1-\theta}}{1-\theta}$, where β is the discount factor.

The banking sector is represented by perfectly competitive financial intermediaries that participate simultaneously in a deposit and in a credit market. In the market for deposits, they announce rates of return of r_t^m for movers and r_t^n for nonmovers, taking competing bank's actions as given. In the credit market, banks offer loans in amount l_t charging an interest rate of R_t per unit of the consumption good borrowed.

The existence of limited communication among banks between locations forbids the

validation of privately-issued liabilities. This is not the the case for fiat currency which is the only asset globally verifiable irrespective of location. This imposes a trading friction on movers as they must prematurely terminate asset investments in exchange for currency, in order to consume. In this manner, money has the role of a medium of exchange despite being return-dominated by all other assets in the economy.

Relocation risk is analogous to a "liquidity-preference shock" as in Diamond and Dybvig (1983) and consequently financial intermediaries arise to provide insurance against liquidity risk. Similarly, because borrowers can take out loans to consume when young in the absence of income, intermediaries also provide intertemporal consumption-smoothing services by supplying loans in the credit market.

The fiscal authority issues debt through bond securities in nominal amount B_t, with real value $b_t \equiv \frac{B_t}{P_t}$ where P_t is the unit price of the consumption good. These liabilities offer a sure-claim of R_t^b per unit of the consumption good invested in government debt. Also, the fiscal authority's income is complemented by transfers from the monetary authority every period.

A monetary authority is represented by an independent central bank (CB) that has at its disposal two monetary policy instruments. First, it regulates the money supply by adhering to the rule $M_t = \sigma M_{t-1}$, where M_t represents current nominal money balances and $\sigma > 1$ is the rate of money growth. Hence, the CB is able to affect the return on real money balances $m_t \equiv \frac{M_t}{P_t}$ which depend on the relative price level $\frac{P_t}{P_{t+1}}$. The second instrument denotes the size of the CB's balance sheet by engaging in an expansionary balance sheet program through government bond purchases in nominal amount B_t^{CB}, whose real value is denoted by $b_t^{CB} \equiv \frac{B_t^{CB}}{P_t}$. Finally, the CB transfers a fraction $\lambda \in (0, 1)$ of its net revenue to the fiscal authority every period.

4.2.1 Timing of Actions

The sequence of actions of depositors and borrowers follows. At the start of period t, depositors are endowed with income y_0 which they fully deposit in the bank. These intermediaries invest deposits in a portfolio of bonds, cash balances and loans supplied in the credit market. Afterwards, borrowers obtain funds to consume when young by

taking on loan debt from intermediaries. Then, the relocation shock is realized and due to limited communication between banks and restrictions on asset portability, moving agents cash out their deposit from the bank. At the end of this period, depositors who have to relocate do so and carry money balances. Now in their old period, borrowers receive an endowment of y_1 which they consume after honoring debt payments. Similarly, nonmovers claim their realized return on deposits. Finally, movers exchange cash for the consumption good with banks and all old agents consume.

4.2.2 Financial Intermediation

The Deposit Market

Financial intermediaries live in a perfectly competitive market and are symmetrical across locations. In this manner, I describe the actions of a representative bank.

Deposits are allocated through an investment portfolio of assets, while at the same time the representative bank announces interest returns on deposits of r_t^m for movers and of r_t^n for nonmovers. It follows that financial intermediation allows movers to consume $c_t^m = r_t^m y_0$ if a mover and $c_t^n = r_t^n y_0$ if a nonmover.

Interest on deposits depend on the bank's investment returns coming from cash m_t, government bonds b_t^P, and loans l_t. The bank is able to guarantee such returns first, to movers, by holding enough currency that takes into account the return on money and the size of the moving population:

$$\pi r_t^m y_0 \leq m_t \frac{P_t}{P_{t+1}}, \tag{4.1}$$

in turn, but for nonmovers, interest rates on deposits are sustained by the returns coming from bonds and loan investments :

$$(1-\pi) r_t^n y_0 \leq R_t^b b_t^P + R_t l_t^s. \tag{4.2}$$

The bank investment allocations follow a balance sheet constraint:

$$y_0 \geq m_t + l_t^s + b_t^p. \tag{4.3}$$

Given that banks are Nash competitors, in equilibrium they offer rates of return that maximize depositor's expected utility:

$$\max_{r_t^m;r_t^n}\left\{\frac{\pi\left(r_t^m y_0\right)^{1-\theta}}{1-\theta}+\frac{(1-\pi)\left(r_t^n y_0\right)^{1-\theta}}{1-\theta}\right\} \tag{4.4}$$

subject to (4.1)-(4.3).

As a result, the bank will hold a proportion of deposits as currency reserves which are decreasing in the oportunity cost of holding money, reflected by inflation and the return on loan investment:

$$\gamma_t \equiv \frac{m_t}{y_{0\ t}} = \frac{1}{1+\left(\frac{1-\pi}{\pi}\right)\left(R_t\frac{P_{t+1}}{P_t}\right)^{\frac{1-\theta}{\theta}}} \tag{4.5}$$

Equation (4.5) describes the optimal risk-sharing condition that allows banks to provide insurance against a random demand for currency.

Also from the bank's first order conditions, a no-arbitrage relationship holds:

$$R_t = R_t^b \tag{4.6}$$

which establishes that the cost of private funds has to equal that of public debt as banks exploit all profit opportunities in order to attract depositors.

The Credit Market

Borrowers are endowed only when old with y_1 units of the consumption good. The fact that they value consumption when young and old makes these individuals seek consumption-smoothing opportunities. Hence, these agents will finance their consumption when young by taking out default-free loans in amount l_t^d at an interest rate of R_t in a credit market such that:

$$\max_{l_t^d}\left\{\frac{(l_t^d)^{1-\theta}}{1-\theta}+\beta\frac{(y_1-R_t l_t^d)^{1-\theta}}{1-\theta}\right\} \tag{4.7}$$

which yields the loan demand function that is increasing in income and decreasing in the cost of borrowing:

$$l_t^d = \frac{y_1}{(\beta R_t)^{\frac{1}{\theta}} + R_t}. \tag{4.8}$$

The market for loans clears so that:

$$l_t^s = l_t^d \tag{4.9}$$

for all $t \geq 0$.

4.2.3 The Central Bank

The CB controls the rate of money growth σ, which generates inflation tax proceeds or seigniorage revenue in amount $\left(\frac{\sigma-1}{\sigma}\right) m_t$ every period. Additionally, the CB engages in a government security purchase program by acquiring bonds in amount b_t^{CB} and collecting investment revenue from the returns on previously issued bonds in amount $R_{t-1}^b b_{t-1}^{CB}$. Thus, the CB resource constraint is depicted by:

$$R_{t-1}^b b_{t-1}^{CB} + \left(\frac{\sigma - 1}{\sigma}\right) m_t - b_t^{CB} > 0. \tag{4.10}$$

The CB's net income is strictly positive as it has the ability to control seigniorage revenue in order to avoid any losses. Finally, every period, the CB transfers a fraction $\lambda \in (0, 1)$ of its net resources to the fiscal authority. These transfers allow monetary policy to influence the impact of public debt in the economy.

4.2.4 The Fiscal Authority

Part of the fiscal authority's income stream comes from the sale of bonds b_t every period. These debt liabilities are purchased by private investors and the monetary authority such that the market for public debt clears:

$$b_t = b_t^{CB} + b_t^P, \tag{4.11}$$

for all $t \geq 0$.

The remaining income resources of the fiscal authority come from CB transfers which consist of a fraction λ of the monetary authority's net receipts generated through monetary policy operations. In turn, debt payments on previously issued debt constitute the expense side of the fiscal authority's budget constraint, so that under a balanced budget:

$$R^b_{t-1}b_{t-1} = b_t + \lambda\left[R^b_{t-1}b^{CB}_{t-1} + \left(\frac{\sigma-1}{\sigma}\right)m_t - b^{CB}_t\right] \tag{4.12}$$

4.3 Steady State Analysis

The steady state properties of the economy follow. First, by (4.6) and (4.8) I construct the no arbitrage locus:

$$l = \frac{y_1}{[\beta R^b]^{\frac{1}{\theta}} + R^b}, \tag{4.13}$$

which inversely relates loan demand with bond interest rates by imposing no arbitrage between the returns to private and public debt.

Next, I obtain a second steady state relationship. Note that in a steady state equilibrium $P_{t+1}/P_t = \sigma$ so that using (4.5) and (4.11) into (4.12) yields:

$$b^P = \lambda\left(\frac{\sigma-1}{\sigma}\right)\left[\frac{\gamma(R,\sigma)\cdot y_0}{R^b-1}\right] - (1-\lambda)b^{CB}, \tag{4.14}$$

The expression in (4.14) illustrates how CB bond purchases impact private bond holdings which are also influenced by the net lending position of the fiscal authority. For instance, when $R^b - 1 > 0$, net real interest rates are positive which implies that the fiscal authority is a net borrower: $b^p > 0$. In this case, an increase in CB bond purchases reduces the amount of public debt in private hands which ameliorates the crowding out effect of government debt, allowing loan investment to increase. In the case where $R^b - 1 < 0$, net real interest rates are negative and the fiscal authority is a net lender: $b^p < 0$. Thus, through bond purchases, the CB is effectively lending resources to the fiscal authority that translate into a higher level of fiscal subsidies to the private sector. It is also important to note that the impact of monetary policy in stimulating

credit market activity increases as the proportion of CB transfers decreases. This fact indicates the importance of the CB's fiscal independence.

I now obtain a third steady state relationship by substituting the value of b^p in (4.14) into the bank's balance sheet constraint in (4.3) and using (4.6) to obtain an expression for the steady state loan level:

$$\frac{l}{y_0} = 1 - \gamma(R^b, \sigma)\left[1 + \frac{\lambda\left(\frac{\sigma-1}{\sigma}\right)}{R^b - 1}\right] + (1-\lambda)\frac{b^{CB}}{y_0}. \tag{4.15}$$

The equation above illustrates important facts about lending in the economy. For instance, higher borrowing costs reflected by an increase in R^b, positively impact loan availability. This expression also illustrates how CB bond purchases increase the fraction of loan to deposits where the magnitude of this effect is determined the degree of transfers to the fiscal authority.

Next, I offer conditions for a steady-state to exist.

Proposition 1. *(Existence of Multiple Steady States). Assume (4.10) holds and let* $\hat{l} \equiv [1 - \pi(1-\lambda)]y_0 + (1-\lambda)b^{CB}$. *Further, assume that borrower's endowments when old are such that:*

$$\frac{y_1}{y_0} > \left[\left(\frac{\beta}{\sigma}\right)^{\frac{1}{\theta}} + \frac{1}{\sigma}\right]\left[1 + (1-\lambda)\left(\frac{b^{CB}}{y_0} - \pi\right)\right].$$

Under these conditions, multiple steady-state equilibria exist. In one, the fiscal authority is a net borrower and credit market activity is low; in the other, the fiscal authority is a net lender and the economy exhibits a high degree of credit market activity.

4.3.1 Comparative Statics

Money Growth Rule

Next, I study the effects of monetary policy in the steady state. Starting with money supply in the economy, the impact of an increase in the rate of money growth is summarized by the following proposition:

Proposition 2. *(Increase in the Rate of Money Growth under Perfectly Competitive*

Banking). Assume that $r^b > \lambda\left(\frac{\sigma-1}{\sigma}\right)$ *and that multiple steady state equilibria exist, then:*

i. When the fiscal authority is a net lender: $\frac{dl}{d\sigma} > 0$, $\frac{dR^b}{d\sigma} < 0$, $\frac{dR}{d\sigma} < 0$.

ii. When the fiscal authority is a net debtor: $\frac{dl}{d\sigma} > 0$, $\frac{dR^b}{d\sigma} < 0$, $\frac{dR}{d\sigma} < 0$, *only if intermediaries' asset substitution effect dominates the distortionary effect of government debt, otherwise:* $\frac{dl}{d\sigma} < 0$, $\frac{dR^b}{d\sigma} > 0$, $\frac{dR}{d\sigma} > 0$.

Increases in the rate of money growth generate two opposing effects. The first has to do with the crowding out effect of government debt. As higher rates of money growth erode the real value of bonds, the fiscal authority has to offer higher returns for the bond market to clear as implied by (4.11). Thus, the fiscal authority issues more debt which further crowds out loan investment. The second effect is determined by an asset substitution effect in intermediaries' portfolios. In this case, inflation deteriorates the value of money, and, in order to maximize the utility of its depositors, the bank will allocate more resources into loans. This effect also implies that increases in the rate of money growth reduce the seigniorage tax base which also reduces the fiscal authority's ability to issue debt. It is also important to highlight that the magnitude of this effect also depends on the risk aversion of a representative depositor. That is, lower risk aversion makes individuals care less for a "balanced" expected utility, causing intermediaries to destine more resources towards higher consumption states. Indeed, such a state comes to bear if the depositor becomes a nonmover: consumption does not depend on the return to money as depicted in (4.2). This fact further increases intermediaries' incentives to reduce cash holdings in favor of loan investment.

By comparison, in the economy with a higher level of credit market activity, the fiscal authority is a net lender and thus higher rates of money growth yield increased seigniorage transfers that allow the fiscal authority to enhance subsidies to the private sector. These resources find their way into loan investment that by (4.9) reduce the cost of private borrowing and ultimately increase lending volume.

Bond Purchase Program

The effect of government security purchases is summarized in the following proposition:

Proposition 3. *(Bond Purchases under Perfectly Competitive Banking). Assume that* $r^b > \lambda\left(\frac{\sigma-1}{\sigma}\right)$ *and that multiple steady state equilibria exist. Then, irrespective of the fiscal authority's net lending position:* $\frac{dl}{db^{CB}} > 0$, $\frac{dR^b}{db^{CB}} < 0$, $\frac{dR}{db^{CB}} < 0$.

When the CB engages in a bond purchase program, it increases the amount of resources to the fiscal authority via transfers. However, unlike resources coming from an increase in the rate of money growth, the CB keeps a fraction $1-\lambda$ of outstanding bonds causing fiscal liabilities to also increase.

When the fiscal authority is a net borrower, CB bond purchases reduce intermediaries' investment opportunities in public debt. Even though there is also transfered income to the fiscal authority, the ultimate outcome is a decline in bond supply for private investors which shifts deposit allocations toward loan investment. For the credit market to clear, the cost of private and public borrowing must go down by condition (4.9).

If the fiscal authority is a net lender, open market operations are effectively lending low cost resources to the fiscal authority. This enhances subsidies to the private sector which allows intermediaries to increase loans. As a result, the cost of borrowing declines by loan market clearing and credit market activity increases.

4.4 A Monopoly Bank

I now focus on an economy in which a single intermediary constitutes the entire financial sector.

Our analysis so far has shown that competition in the banking system has important implications for the transmission mechanism of monetary policy. Moreover, the transmission mechanism of monetary policy is (potentially) distorted by the crowding out effects of government debt in the case of an increase in the rate of money growth. When the banking sector is fully concentrated, there is another distortion in this mechanism as now the monopoly bank can behave strategically by exercising market power. As the sole intermediary that provides risk-sharing and consumption-smoothing services, it controls the allocation of deposits in order to charge interest rates that extract the maximum amount of surplus in the credit market. Furthermore, the monopoly bank utilizes gov-

ernment bonds as another source of revenue further putting downward pressure on cash reserves and in detriment of risk-sharing. It follows that the monopoly bank simultaneously distorts both deposit and credit markets which has important implications for the impact of monetary policy.

When the banking sector is perfectly competitive, intermediaries invest in money balances according to an optimal risk-sharing condition. They also invest in loans and bonds up to the point at which no arbitrage guarantees the maximum return on debt investment for its clients. As opposed to this scenario, a monopoly bank will choose the amount of assets and the rates of return on loans that extract the maximum amount of surplus from its depositors taking the return to government debt as given:

$$\max_{r_t^m; r_t^n; l_t; b_t^p; m_t} \left\{ R(l_t) l_t + R_t^b b_t^p + m_t \cdot \frac{P_t}{P_{t+1}} - \pi r_t^m y_0 - (1-\pi) r_t^n y_0 \right\}. \tag{4.16}$$

However, the bank must offer returns on deposits that guarantee a baseline expected utility level $\bar{u}$ that makes individuals indifferent between participating in the financial system and autarky:

$$\frac{\pi (r_t^m y_0)^{1-\theta}}{1-\theta} + \frac{(1-\pi)(r_t^n y_0)^{1-\theta}}{1-\theta} \geq \bar{u}. \tag{4.17}$$

Given that money is dominated in rate of return, the bank will hold money balances and guarantee returns to movers such that:

$$\pi r_t^m y_0 = m_t \cdot \frac{P_t}{P_{t+1}}. \tag{4.18}$$

In contrast, it will extract all possible surplus from investment in loans and government debt offering returns to nonmovers that satisfy:

$$(1-\pi) r_t^n y_0 < R(l_t) l_t + R_t^b b_t^p, \tag{4.19}$$

subject to a balance sheet constraint:

$$y_0 = m + l_t + b_t^p. \tag{4.20}$$

The bank must also make sure that depositors do not lie about their type in attempting to get higher returns on their deposits. Thus it must make sure that the following incentive-compatibility constraint on returns holds:

$$r_t^n \geq r_t^m. \tag{4.21}$$

Notice that the bank's problem can be reduced to choosing the amount of loans and bonds given that cash is return-dominated and therefore it is a residual investment:

$$\max_{r_t^n; l; b_t^p} \left\{ R(l_t) l_t + R_t^b b_t^p - (1-\pi) r_t^n y_0 \right\}.$$

subject to (4.19)-(4.21).

The solution to the bank's problem implies that the optimal amount of loans $l_t^*$and bonds b_t^* will be such that the marginal benefit from both investments is the same:

$$R_t^b = R_t'(l_t^*) l_t + R_t(l_t^*). \tag{4.22}$$

Recall that in a competitive banking sector, intermediation results in a no-arbitrage condition in which the cost of public and private borrowing is the same: $R_t^b = R_t$. In contrast, expression (4.22) highlights the fact that the bank's market power allows it to charge higher interest rates in the credit market making the cost of private sector funding to be greatern than that of public funds. Such a gap allows the bank to extract the maximum amount of surplus in both types of debt markets given that it faces a downward demand curve.

Also from the bank's first order conditions, the amount of money that the bank will hold is completely residual after choosing a combined amount of loans and bonds that solve (4.22) and follow:

$$m_t = y_0 - (l_t^* + b_t^{p*}),$$

where:

$$\gamma_t^M \equiv \frac{m_t}{y_0} = \frac{P_{t+1}}{P_t} \cdot \left[\frac{\bar{u}(1-\theta)/\pi^\theta}{1 + \left(\frac{1-\pi}{\pi}\right)\left(\frac{P_{t+1}}{P_t} \cdot R_t\right)^{\frac{1-\theta}{\theta}}} \right]^{\frac{1}{1-\theta}}. \tag{4.23}$$

4.5 Steady State Analysis

The analysis of the economy in the steady-state follows. The next proposition determines the conditions for the existence of a steady state:

Proposition 4. *(Existence of Multiple Steady-States under Fully-Concentrated Banking). Let* $y_d \equiv [\bar{u}(1-\theta)]^{\frac{1}{1-\theta}} \left[(1-\pi)^{\frac{1+\theta}{1-\theta}} + \pi\right]$ *and* $\theta = \frac{1}{2}$. *Also, let* $\underline{l} \equiv y_0 - [\bar{u}(1-\theta)]^{\frac{1}{1-\theta}}\pi\sigma$ *and assume that* $y_0 > y_d$. *Then, if endowments of old borrowers are such that:*

$$y_1 > max\left\{ \left[y_0 - (\bar{u}/2)^2\pi\sigma\right]\left[(\beta/\sigma)^2 + \sigma^{-1}\right],\ \frac{y_0 + (1-\lambda)(b^{CB} - \pi y_0)}{\beta\left[(\sigma+\beta^2)^{1/2} - 2\beta\right]} \right\},$$

multiple steady-state equilibria exist in which a fully-concentrated banking system coexists with a fiscal authority that is a net lender in one equilibrium and a net borrower in the other.

The first assumption on the endowment of depositors guarantees that the monopoly bank is earning positive profits in equilibrium. Moreover, this condition allows the bank to be profitable while making sure that the incentive compatibility constraint in (4.21) holds: $l > \underline{l}$.

The second assumption on the endowment of old borrowers establishes that money is dominated in rate of return by loans and as well as by bond investments. This condition assures that independently of the fiscal authority's net lending position, there will an equilibrium in the credit market.

In this case, I also obtain two relationships that along with the bank's choice of loans determine the amount of loans in a steady state equilibrium. The first one is similar to expression (4.15) but with cash holdings determined by (4.23):

$$\frac{l}{y_0} = 1 - \gamma^M(R^b, \sigma)\left[1 + \frac{\lambda\left(\frac{\sigma-1}{\sigma}\right)}{R^b - 1}\right] + (1-\lambda)\frac{b^{CB}}{y_0}. \tag{4.24}$$

The second relationship is a no-arbitrage condition depicted by:

$$l = \frac{\left(1 + 2\beta^2 R^b\right)\beta y_1}{\left[R^b\left(1+\beta^2 R^b\right)\right]^{\frac{1}{2}}} - 2\beta^2 y_1. \tag{4.25}$$

4.5.1 Comparative Statics

Next, I analyze the effects of monetary policy on the credit market by starting with changes in the CB's money growth rule and afterwards discussing the implications of a bond purchase program.

Money Growth Rule

I first discuss the effect of an increase in the rate of money growth on the amount of lending volume in the economy.

Proposition 5. *(Increase in the Rate of Money Growth under Fully-Concentrated Banking). Let* $I \equiv \sigma R^b$ *and* $\bar{I} \equiv \frac{\pi}{1-\pi}$. *Then, in response to an increase in the rate of money growth:*

i. $\frac{dl}{d\sigma} > 0, \frac{dR}{d\sigma} < 0, \frac{dR^b}{d\sigma} < 0$ *, if the size of the liquidity shock is such that* $\pi \leq \frac{1}{2}$ *or, if* $\pi > 1/2$ *and* $I > \bar{I}$.

ii. $\frac{dl}{d\sigma} < 0, \frac{dR}{d\sigma} > 0, \frac{dR^b}{d\sigma} > 0$, *if the size of the liquidity shock is such that* $\pi > 1/2$ *and* $I < \bar{I}$.

This proposition illustrates the strategic behavior of the monopoly bank relative to the competitive banking case. An increase in the rate of money growth decreases the value of money and absent any asset reallocations by banks, less risk-sharing is available for depositors. In a perfectly competitive bank$\bar{R^b}$ing sector, intermediaries reduce their

cash reserves by investing more resources into higher-yielding assets such as loans and bonds, in aim of maximizing their clients expected utility. The monopoly bank will also rebalance deposit allocations but in contrast, it may increase the amount of risk-sharing and reduce loan investments that increase the cost of borrowing. This is because in order keep distorting the credit and bond markets, the bank needs to maintain the size of its deposit base. Unlike the competitive banking sector, depositors are not being compensated as much (ex-ante) with higher-yielding asset substitutions when risk sharing declines. This fact affects their incentives to participate in the financial system. As a result, the monopoly bank will adjust the level of risk sharing by taking into account the trade off between a reduction in the size of its deposit base and the opportunity cost of cash as implied by nominal interest rates.

Also, proposition 5 suggests that when the fiscal authority is a net borrower, an increase in the rate of money growth can magnify the crowding out effect of government debt under an economy with high liquidity shocks and low interest rates. This is in contrast to the competitive banking case in which the asset substitution effect is always counter to government debt distortions when the CB increases the rate of money growth.

For the case in which the fiscal authority is a net lender and under a similar, high liquidity shock and low interest rate economy, the distortions on the transmission mechanism of monetary policy prevail. In this case however, a fully concentrated banking sector compromises the ability of the fiscal authority to subsidize credit market activity. That is, the monopoly bank dedicates these low-cost resources coming from the fiscal authority towards cash reserves in an attempt to maintain the size of its deposit base. This is in detriment of a higher loan supply and causes even higher interest rates. This potential outcome of an increase in the rate of money growth when the fiscal authority is a net lender, is in stark contrast to the case of a competitive banking sector.

Bond Purchase Program

The impact of an increase in the size of the CB's balance sheet on credit markets is summarized in the following proposition:

Proposition 6. *(Bond Purchases under Fully-Concentrated Banking). Irrespective of the net lending position of the fiscal authority:* $\frac{dl}{db^{CB}} > 0, \frac{dR}{db^{CB}} < 0, \frac{dR^b}{db^{CB}} < 0$.

For the case in which the fiscal authority is a net borrower, CB bond purchases translates into greater income for the fiscal authority. Consequently, the fiscal authority doesn't need to pay as much on bonds so that the return to these securities decreases. This CB action also causes the supply of bonds for private investment to decrease, consequently, opportunities and returns from public debt investment decline, the monopoly bank adjusts its portfolio so as to maintain maximal profit levels. As I describe this process, first note that the marginal benefit of bond investment, or R^b, has declined. Because the monopoly bank operates in the elastic part of the demand curve and chooses l and b^p up until their marginal benefit is the same, it will increase its loan supply to the credit market up until these marginal conditions are again equal. Because the bank faces a downward-sloping loan demand curve, for this process to take place, the cost of private borrowing must go down. After achieving its profit-maximizing loan supply, the remaining resources will be destined towards cash balances.

When the government is a net lender to the private sector, aside from reducing the supply of government debt, CB bond purchases represent low-cost lending to the fiscal authority. This implies that the fiscal authority does not have to pay as much for its debt liabilities or equivalently, the cost of servicing its debt declines. This translates into increased subsidies to the private sector. From the bank's perspective, the net marginal benefit of bond holdings has gone up, which makes investment in these securities more attractive. However, as the CB reduces the supply of bonds that would otherwise end up in private hands, the bank will reallocate its deposit income to greater loan investments up until the marginal benefit of loans and bonds is the same. The remaining deposit income will again go towards cash holdings.

Thus, CB bond purchases stimulate credit market activity not only by reducing the distortionary effects of government debt but also by reducing the credit market distortions that come about from the existence of market power in the financial system. This is reflected by a greater lending volume and lower loan interest rates as well as by a re-

duction in the "gap" between private and public borrowing costs. Moreover, this policy improves risk-sharing by increasing liquidity in the economy despite the presence of fully concentrated banking. That is, as the monopoly bank is able to extract surplus from its depositors and borrowers, it is better off moving away from low-yield short-term cash investments as much as possible and allocating more resources into longer-term investment projects. Interestingly, CB bond purchases counter such outcome by aligning the bank's distortionary incentives so as to ultimately favor higher cash investments while at the same time increasing longer-term credit market activity.

4.6 Discussion

Now I analyze the differences and similarities of the effects of this policy when there is a perfectly competitive versus a fully-concentrated banking sector. First, and irrespective of intermediaries' industrial organization, in the economy with low credit market activity, CB bond purchases cause banks to destine more resources into loans and cash balances. However, when banks lack market power, the only existing distortion in the credit market comes from government debt. Thus, CB bond purchases work by countering such distortion so that banks reallocate resources as dictated by optimal risk-sharing and maximum expected returns to depositors. In this case, the end result of monetary policy is a higher level of risk-sharing and expected consumption levels for depositors as well as increased consumption-smoothing opportunities for borrowers. In contrast, under fully-concentrated intermediation, the impact of CB purchases faces and additional distortion coming from the bank's strategic behavior. Specifically, I have shown that under this monetary policy, even though lending activity increases, the bank has no incentives to provide loans beyond the point at which it is extracting the most surplus from its depositors. As investment in cash is residual, risk-sharing in the economy ceases to be optimal but just enough to incentivize participation in the deposit market. Furthermore, the existence of an interest rate gap between private and public borrowing persists, which indicates unused investment opportunities in stark contrast to the competitive case.

In the economy with high credit market activity, it was seen that CB bond purchases

stimulate the credit market regardless of the competitive structure of the banking system. Nonetheless, the distortionary effects of the price-setting behavior of the financial intermediary persist despite the complementarity of government subsidies to the private sector. Again, as in the alternate economy, this leads to a reduced impact of monetary policy manifested by comparatively inferior levels of risk-sharing for depositors and lower consumption-smoothing opportunities for borrowers.

4.7 Conclusions

The recent financial crisis forced central banks around the world to resort to unconventional policy instruments. A noticeable example was the unprecedented expansion in the size of their balance sheets through the purchase of government securities. At the same time, the market concentration in the banking systems of major economies accelerated. In this paper, I analyze the implications of competition in the banking sector for the ability of expansionary balance sheet policies to affect credit market activity. Under this objective I also explore conventional instruments such as a rate of money growth. Specifically, I analyze this issue in a framework in which banks simultaneously offer risk-sharing and intertemporal consumption-smoothing services in the presence of government debt. Our results suggest that under perfectly competitive banks, increased rates of money growth reduce interest rates and increase loan volume. This also holds in high debt economies if the crowding out effect of government debt is low. Similarly, central bank bond purchases unambiguously promote credit market activity. In contrast, under a monopoly bank, higher rates of money growth reduce funding costs and promote lending except for when the opportunity cost of money is low and liquidity shocks are of considerable magnitude. Further, bond purchases by the central bank unambiguously stimulate credit activity but the effect is lower relative to perfectly competitive banks if the economy is under a low interest rate regime.

This analysis highlights the need for further studies in the transmission mechanism of unconventional monetary policy given the ongoing levels of banking market concentration. Given that I present a framework in which there is a well-defined role for intermediaries,

our approach can be used as a stepping stone to answer other aspects that shed light on the conduct of unconventional monetary policy. For example, the role of bank competition on the impact of monetary policy in corporate credit markets is of interest. Another interesting issue relevant to international monetary policy coordination, would be the cross-border effects of monetary policy under changes in the industrial organization of the banking sector.

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