Fiscal Policy Transmission:
Stimulus with a Lending Friction*

Ryan Scott Eiben†

Abstract

The aftermath of the financial crisis has renewed interest in the effects of fiscal policy in the macroeconomy, particularly as a source of stimulation. The impetus for this reinvigorated literature was the breakdown of normal financial market operation. It should come as a surprise that financial markets and their frictions have been conspicuously absent from studies of fiscal transmission. The present paper takes steps to address this issue through the development of a limited participation model with flexible prices, distortionary taxes, and a costly lending technology. Preliminary results suggest that the way costly lending is introduced may not be as important for fiscal transmission in different monetary-fiscal policy regimes as the fact that some investment must be financed.

Keywords: Fiscal theory of the price level; Financial frictions; Limited participation; Fiscal Transmission; Present Value Multipliers; Fiscal Policy

JEL classification: E130, E220, E440, E620

1 Introduction

Fiscal multipliers are presently a fertile area of research as policymakers and academics alike aim to quantify the effects of macroeconomic interventions. The renewed interest follows directly from policy debates surrounding the appropriate size and composition of such interventions during and following the Great Recession. However, economists are far from a consensus. This follows in great part from the modeling and prior assumptions of the researchers as demonstrated by Leeper et al. (2011). Indeed, part of the art of modeling is selecting which features of the economy to emphasize as sources of exogeneity and propagation that the researcher feels are central.

Following the financial crisis, financial frictions have begun to receive more attention as a modeling feature for obvious reasons. Drautzburg and Uhlig (2011) echo the sentiment as their estimation of a model with stochastic risk premia ascribes much of the movement in the recent data to the processes driving interest rate spreads.¹ Strangely enough, attempts to measure fiscal effects have relied on models where financial markets have been conspicuously absent. Given that the impetus for examining fiscal multipliers has been the financial crisis and the Great Recession, this omission seems odd and one that I hope to address. That being said, the extent to which economists have attempted to examine how financial frictions affect fiscal transmission has focused on the role of asymmetric information in lending contracts a la Bernanke et al. (1999)². What we have learned so far is that fiscal stimulus in these economies can be quite large because

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†Department of Economics, Indiana University, 100 S. Woodlawn, Bloomington, IN 47405; email: reiben@indiana.edu.

1As a result of their finding, the authors specifically state that “Understanding [financial frictions’] nature more deeply should therefore be high on the research agenda” though they leave the effects of the frictions unsatisfactorily explored.

2For examples, see Carrillo and Poilly (2013) and Zuo (2011).
the increase in net worths caused by higher public spending reduces the costs of asymmetric information leading to lower financing costs and further increased private sector spending.

Asymmetric information is not the whole story, though. For instance Goodfriend and McCallum (2007) show that a fully modeled banking sector facing convex intermediation costs can actually attenuate expansions rather than accelerate them. Their focus is on the fact that there are costs of intermediation that can be tied to a production function for loans. One interpretation of this view is that regulation can be a source of these costs in addition to the fact that employees and capital must be employed to facilitate loan provision. It is this latter characteristic of banking and its consequence for fiscal policy transmission that I intend to explore in this paper.

Another important feature of real world fiscal policy is that taxes that are used to finance spending, along with nominal debt, are distortionary in nature, however, much of the literature on fiscal multipliers simplifies the analysis by utilizing lump-sum taxes. As such, this paper will also seek to understand the role of distortionary taxation in fiscal policy transmission as well relative to the lump-sum benchmark. Drautzburg and Uhlig (2011) is perhaps the closest work in the spirit of the present paper in that they seek to understand the role distortionary taxes as well, but, their work differs substantially from my own. The most obvious is that theirs is an extended version of Smets and Wouters (2007) whereas mine is a flexible price model. Needless to say, theirs is a model whose dynamics can be much richer than my own. They also introduce financial frictions via the inclusion of credit constraint households who act as rule-of-thumb consumers. My model features limited participation via the inclusion of distinct households who choose to participate in only a subset of all available assets to get at the role of financial intermediation in channeling funds from savers to investors.

The remainder of the paper will read as follows. Section 2 will lay out the key elements of the model used in this paper's analysis. Section 3 will discuss some basic exercises. Section 4 will point out further developments to anticipate in the near term for this paper.

2 Model

This paper employs a model that features limited participation and flexible prices. The cost of invoking limited participation is that I abstract from the incentives that cause real world agents to substitute among all assets in the economy, however, I do not think that this is a terrible assumption. I believe, instead, that segmenting the population by savings behavior captures the idea that some investments are made available to some households only through the services of financial intermediaries that collect and channel funds to borrowers seizing upon investment opportunities. Furthermore, limited participation models have become one of two norms for economists studying the role of financial markets in the macroeconomy of which the financial accelerator model popularized in Bernanke et al. (1999) is the most prominent example.4

The model consists of three types of agents: two households called depositors and investors as well as a representative firm. In addition there exist monetary and fiscal authorities. A description of each follows.

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3Hence the name "financial accelerator".

4The other norm is a Bewley-style heterogeneous agents model. A primary difference between limited participation and heterogeneous agents models in this setting is that the former highlights the role of loanable funds in facilitating production through financing whereas the latter focuses on how savings can facilitate the redistribution of aggregate income.
Depositors

Depositors choose a sequence of consumption \((c_t^d)\), labor \((n_t^d)\), and savings \((s_t)\) to solve the following problem:

\[
\max_{c_t^d, n_t^d, s_t} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[ \frac{(c_t^d)^{1-\sigma_d}}{1 - \sigma_d} - \frac{\chi_d (n_t^d)^{1+1/\eta_d}}{1 + 1/\eta_d} \right] \right\}
\]

s.t. \(c_t^d + s_t = (1 - \tau_t^d)w_t^d n_t^d + \frac{R_{t-1}}{\pi_t} s_{t-1} + (1 - \omega)T \)

\(c_t^d, s_t \geq 0, \quad n_t^d \in [0, 1]\)

To clarify notation, \(w_t^d\) representing the depositor’s wage, \(\tau_t^d\) the depositor’s tax rate, \(R_t\) the gross nominal interest rate deposits earn on their savings, and \(\pi_t\) is inflation between periods \(t-1\) and \(t\). Parameters in the problem are the discount factor \((\beta)\), coefficient of relative risk aversion \((\sigma_d)\), frisch elasticity \((\eta_d)\), and a calibrating parameter \((\chi_d)\) so I can achieve a desired debt-to-GDP ratio in steady state. The last term in the budget represents lump-sum transfer from the government. \(T\) is total transfers to households and \((1 - \omega)\) is the depositors’ share. There is no time subscript on this term as I aim to investigate how restricting the fiscal authority’s tax choices to adjusting tax rates affects the transmission of fiscal policy in this model. The inclusion of the lump-sum term simply allows me to achieve a desired debt-to-GDP ratio in steady state. Assuming an interior solution, depositors’ margins are standard.

\[
\chi_d (n_t^d)^{1/\eta_d} = (1 - \tau_t^d)w_t^d (c_t^d)^{-\sigma_d} \quad (1)
\]

\[
(c_t^d)^{-\sigma_d} = \beta E_0 \left\{ (c_{t+1}^d)^{-\sigma_d} \frac{R_t}{\pi_{t+1}} \right\} \quad (2)
\]

Equation (1) states that the marginal utility sacrificed to labor a bit more must equal the marginal utility gained by consuming the resulting after tax earnings while equation (2) says that the marginal utility sacrificed to save a bit more must equal the marginal utility gained by consuming the proceeds of the marginal savings discounted to present.

Investors

Investors choose a sequence of consumption \((c_t^i)\), labor \((n_t^i)\), loans \((l_t)\), and capital \((k_t)\) to solve:

\[
\max_{c_t^i, l_t, n_t^i, k_t} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left[ \frac{(c_t^i)^{1-\sigma_i}}{1 - \sigma_i} - \chi_i (n_t^i)^{1+1/\eta_i} \right] \right\}
\]

s.t. \(c_t^i + k_t + \frac{R_{t-1}^l}{\pi_t} l_{t-1} = (1 - \tau_t^i)w_t^i n_t^i + l_t + (1 - \tau_t^k)R_t^l k_{t-1} + \omega T \)

\(1 - \mu)k_t \leq l_t \quad c_t^i, k_t, l_t \geq 0, \quad n_t^i \in [0, 1]\)

The notation is the same as in the depositors’ problem except with index \(d\) replaced with \(i\). The additional parameter \(\mu\) allows for the calibration of an exogenous leverage ratio \((1/\mu)\). The idea here is that investment is financed by either the issuance of debt or equity. In this model, the former is achieved through loans from an intermediation technology which will be described below. The gross nominal interest rate on these loans is denoted \(R_t^l\). The equity finance is assumed to come straight out of investors’ own after tax labor and capital earnings net of loan repayment.\(^5\)

\(^5\)The exogeneity of the leverage ratio is worth discussing briefly. Its natural for one to want to endogenize investors’ choice of the equity-debt financing mix. I argue that this sentiment is more important if one is trying to explain how fluctuations...
I assume capital fully depreciates each period and claim that the finance constraint will always bind in equilibrium. This is because it is optimal to have strictly positive capital in every period and the investor must still make interest payments on loans that are in excess of what is required. Thus, optimization can take place with respect to a consolidated budget constraint.

\[
c'_t + \mu_k = (1 - \tau_t)w_i^i + \left( (1 - \tau_t^k)R_t^k - (1 - \mu) \frac{R_{t-1}^l}{\pi} \right) k_{t-1} + \omega_T \tag{3}
\]

Equation (3) shows the interesting nature of the investment problem. Expectations of capital taxes, the marginal product of capital, and inflation will all intermingle to determine how much capital the investor wants to obtain. Assuming an interior solution, the investors’ margins are:

\[
\chi_i(n_i^1)^{1/\omega_i} = (1 - \tau_t)w_i^i(c_i^0)^{-\sigma_d} \tag{4}
\]
\[
(c_i^0)^{-\sigma_i} = \frac{\beta}{\mu} E_t \left\{ (c_{i+1}^0)^{-\sigma_i} \left[ (1 - \tau_{t+1}^k)R_{t+1}^k - (1 - \mu) \frac{R_{t+1}^l}{\pi_{t+1}} \right] \right\} \tag{5}
\]

The interpretation of (4) is the same as that of (1). The difference in interpretation between (5) and (2) is simply the precise nature of the pecuniary returns. The financial return to saving for an investor is simply the after tax rental rate net of loan repayments.

**Representative Firm**

Product and factor markets are all perfectly competitive. The representative firm maximizes profit subject to a cobb-douglas production function. Specifically, production is given by

\[
Y_t = A_t^\alpha (A_t^k)^{\omega_i} (A_t^d)^{1-\omega_i} \tag{6}
\]

which implies competitive factor prices of

\[
R_t^k = \alpha \frac{Y_t}{k_{t-1}} \tag{7}
\]
\[
w_t^d = (1 - \omega)(1 - \alpha) \frac{Y_t}{n_t^d} \tag{8}
\]
\[
w_t^i = \omega(1 - \alpha) \frac{Y_t}{n_t^i} \tag{9}
\]

**Monetary and Fiscal Policy**

The monetary authority is assumed to set nominal interest rates according to a simple Taylor rule in log-linear form.

\[
\tilde{R}_t = \phi_{\pi} \tilde{\pi}_t + \varepsilon_t^R \tag{10}
\]

in the market valuation of firms were to affect the choices of households who own them, of course assuming one has a model where a Modigliani-Miller theorem does not hold, but this is not the nature of the present paper’s exploration. Instead, I take as given that some fraction of investment in the real world is financed via debt and seek to understand how this fact can alter fiscal transmission.

It has been brought to my attention that if loan rates are exceptionally low that an investor may wish to take out additional loans to finance further consumption leading to a non-binding finance constraint. My intuition says that this event would not be likely to occur in equilibrium since depositors must then have a high rate of savings precisely when the incentive to do so is small. This is something I need to verify rigorously, though. For the time being, I suppose the constraint always binds.
\( \phi \) is the elasticity of the nominal interest rate at which depositors can save relative to contemporaneous inflation. Fiscal policy rules in log-linear form are assumed to be

\[
\begin{align*}
\tilde{g}_t &= \rho_g \tilde{b}_{t-1} + \varepsilon^d_t \\
\tilde{\tau}^d_t &= \gamma_d \tilde{b}_{t-1} - \tilde{g}_t + \varepsilon^d_t \\
\tilde{\tau}^i_t &= \gamma_i \tilde{b}_{t-1} - \tilde{g}_t + \varepsilon^i_t \\
\tilde{\tau}^k_t &= \gamma_k \tilde{b}_{t-1} - \tilde{g}_t + \varepsilon^k_t
\end{align*}
\]

(11)

(12)

(13)

(14)

where all \( \varepsilon_t \)'s are distributed iid \( N(0, 1) \). Tilde's signify log deviations from steady state values. The intuition behind the posited tax rules comes from the simple lump-sum tax rules employed in other work on monetary and fiscal policy interactions. In those rules, the researcher specifies how a quantity of tax revenues responds to the stock of real debt outstanding. With tax rates, \( \tilde{\tau}_t + \tilde{g}_t \) represents the change in the quantity of tax revenue from a particular source. The government’s budget constraint is given as

\[
g_t + \frac{R_{t-1}}{\pi_t} b_{t-1} + T = \tau^d_t w^d_t n^d_t + \tau^i_t w^i_t n^i_t + \tau^k_t R^k_t k_{t-1} + b_t
\]

(15)

**Intermediation Technology & Market Clearing**

The intermediation technology available to this economy is taken from Curdia and Woodford (2010) and represents a simple way to introduce costly intermediation into a model for purposes of generating credit spreads.

\[
R^t_i = (1 + A^t_{i\theta}) R_t
\]

(16)

The term \( A^t_{i\theta} \) represents a real resource cost to utilizing the intermediation technology which has the effect of reducing steady state capital relative to a zero credit spread environment. One could interpret this technology as being provided by some financial intermediary in which case the derivation of a credit spread like (16) is included in the appendix to this paper.

In addition to standard factor market clearing conditions, two other markets deserve brief mention. The funds market clearing condition requires that total savings in the economy be either lent to investors or to government.

\[
s_t = b_t + (1 - \mu) k_t
\]

(17)

The goods market clearing condition is says that all aggregate output is used for some purpose.

\[
c^d_t + c^i_t + k_t + g_t + (1 - \mu) A^t_{i-1} k^1_{i-1} = Y_t
\]

(18)

The latter most term on the left represents intermediation costs for this economy.

With the full model specified, I now turn to a preliminary examination of fiscal transmission as affected by the finance constraint, intermediation technology, and distortionary taxation. I utilize a first order approximation of the model around its deterministic steady state for each exercise. The linearized model can be found in the appendix of this document as well.
3 Exploring Fiscal Effects

In order to gauge the importance of the finance constraint and intermediation costs to fiscal transmission, I ultimately want to appeal to the use of fiscal multipliers as a summary statistic. However, I undertake the computation of determinacy regions and simulate impulse responses to obtain some intuition first. Each exercise is described below.

3.1 Determinacy

A major insight of Leeper (1991) is that monetary and fiscal policies interact to determine inflation and stabilize public debt. With two policy authorities, each capable of managing only one task, we can identify two subsets in the policy parameter space where determinate equilibria spring forth, each with distinct equilibrium properties. In this sense, to understand the effect of the financial friction on fiscal transmission, I first set out to understand how sensitive are the bounds on the two determinate regions in three versions of the model: 1) the fully specified model above, 2) with the finance constraint but no interest rate spread, 3) no finance constraint and no interest rate spread. In all models, I still use the limited participation framework, but in the latter two I set $A_t = 0$ for all $t$.

To study determinacy in the policy parameter space as transparently as possible, I first select a single vector of non-policy parameters and steady states which will be common to all applicable versions of the model in this exercise. They are reported in table 1.

Table 1: Calibration

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>0.99</td>
<td>$\alpha$</td>
<td>0.36</td>
</tr>
<tr>
<td>$\sigma^d$</td>
<td>2.00</td>
<td>$\eta^d$</td>
<td>1.00</td>
</tr>
<tr>
<td>$\sigma^i$</td>
<td>2.00</td>
<td>$\eta^i$</td>
<td>1.00</td>
</tr>
<tr>
<td>$\theta$</td>
<td>1.65</td>
<td>$\omega$</td>
<td>0.50</td>
</tr>
<tr>
<td>$\mu$</td>
<td>0.20</td>
<td>$\rho_g$</td>
<td>0.80</td>
</tr>
</tbody>
</table>

S.S. Value | S.S. Value
---|---
$A = A^i = A^d = A^k = A^t$ | 1.00
$n^i = n^d$ | 0.33
$\tau^i = \pi^k$ | 0.30
$\tau^k$ | 0.25
$g/Y$ | 0.20
$b/Y$ | 0.60

I also assume that all tax rules share a common elasticity of the tax rate to lagged real debt denoted as $\gamma$ to reduce the dimension of the exercise to two as opposed to four. I then lay down a fine grid in a subset of $(\phi, \gamma)$ space defined by $\phi \in [0, 1.5]$ and $\gamma \in [-0.1, 1]$ followed by a search for combinations of parameters that satisfy existence and uniqueness conditions laid out in Sims (2001). The reported bounds on determinacy regions are only approximations, though, as I examine determinacy on parameter values in increments of 0.025 and do not examine determinacy outside the original subset.\(^7\) The results are provided in table 2.

Two observations of note spring forth from the the table. The first is that in all variants of this model, dynamics are decoupled as the bounds on the elasticity in the monetary policy rule are unaffected by the specific model in question. This is, I believe, attributable to all three model variants entailing flexible prices with interest rates not directly being set with regard to output. The second, though, is that the elasticity in the tax rules is quite sensitive to the model variant with the first two models implying qualitatively different implications for tax rate elasticities than the last model. One way to rationalize the latter result is that

\(^7\)I intend to remedy this for the final paper.
Table 2: Determinacy Regions

Model 1: Lim. Part., Fin. Constraint, Intermediation Costs

Region 1: \(0.05 \leq \gamma \leq 0.35\) \(\phi_\pi \leq 1\)
Region 2: \(\gamma > 0.35\) \(\phi_\pi > 1\)

Model 2: Lim. Part., Fin. Constraint, No Intermediation Costs

Region 1: \(0.025 \leq \gamma \leq 0.60\) \(\phi_\pi \leq 1\)
Region 2: \(\gamma > 0.60\) \(\phi_\pi > 1\)

Model 3: Lim. Part., No Fin. Constraint, No Intermediation Costs

Region 1: \(-0.10 \leq \gamma \leq 0\) \(\phi_\pi \leq 1\)
Region 2: \(\gamma > 0\) \(\phi_\pi > 1\)

output may end up having an elasticity of larger magnitude with respect to tax rates when the finance constraint is operative. Crucial here will be the response of the savings behavior of depositors as this action combined with the rate of government debt growth will determine how many funds are available for investors to facilitate production. This yearns for an analytic exploration, however, I postpone this task for a later version of this paper.

3.2 Simulation

While the model in this paper is not capable at speaking directly to dynamics of fiscal stimulus at the zero lower bound, understanding how financing requirements affect stimulus in an environment when the monetary authority is only weakly responding to inflation is, in my opinion, desirable. As such, the simulation that I turn to next is that of impulse response functions to a one-percent positive shock to government spending in region 1 of the parameter space. It is only possible to perform this simulation with a common vector of parameters for models one and two since region 1 of model three does not intersect region 1 of the aforementioned. I use the same calibration for this exercise as seen in table 1 with \(\phi_\pi = 0.5\) and \(\gamma = 0.25\).\(^8\)

As I am after the effects of stimulus, I plot impulse responses functions of the directly relevant objects: output, consumption, capital (investment), inflation, and the real interest rate. Movements in the nominal rate are inferred from the latter two by the fisher equation.

Several features of the two simulations are observable from the figures. Foremost is that the intermediation costs appears to do little to quantitatively change the impulse response functions let alone qualitatively change them. This may ultimately suggest that for the given financial features in this model, further investigation of the financing constraint is of primary desert.

The next observation is the quite non-standard increase in the real interest rate given that policy parameters have been selected so that total revenues should weakly respond to debt. Increases in government consumption have been shown to reduce the real interest rate in models with active fiscal policy and passive monetary policy and lump-sum taxation. At this point, it is unclear what exactly is driving this phenomenon, the finance constraint or the distortionary taxes.

The other side of this story is that we see inflation falling when one would expect inflation to rise in the active fiscal/passive money environment. Understanding this result is likely the key to the result. The

\(^8\)Though not included in this paper, after trying several alternate pairs of policy elasticities selected from region 1, it appears the results of this section do not qualitatively change.
intuition comes from the intertemporal equilibrium condition (ie: recursive substitution of the government’s budget into itself with expectations taken) which is most generally given by

$$b_{t-1} \frac{1}{\pi_t} = E_t \left\{ \sum_{j=0}^{\infty} S(g_{t+j}, T_{t+j}) \prod_{k=0}^{j} r_{t+k}^{-1} \right\}$$

(19)

where $S(\cdot)$ is the expression for primary surpluses, $T_t$ represents tax revenues collected in period $t$, and $r_t$ is the real interest rate at time $t$. One can interpret (19) as an asset pricing equation with agents valuing the stock of bonds outstanding according to the expected discounted value of surpluses much in the same way as households would value an equity based on the expected stream of dividends.

In most models, government bonds are purchased by a single representative agent in which case $T$ on the right hand side of (19) represents their own anticipated tax burden. All an agent would need to do to determine fiscal backing is pay attention to their own expected taxes. No additional source of backing can leak into the agents’ valuation of debt. In the present model, $T$ is a vector that includes taxes raised from those who participate in the debt market and those who do not. This allows for fiscal backing to leak into (19) which depositors use to value public bonds, effectively raising demand for this instrument and driving the price level down. This could happen even if government only weakly adjusts tax revenues to debt outstanding.

While this view is preliminary, a purely theoretical exercise that I can undertake to scrutinize this view is to shut down the accumulation of tax revenues from investors in order to eliminate possible leakage into depositors valuation of public debt and determine whether the standard result of higher inflation and a lower real rate takes hold. Unfortunately, this exercise is postponed to a later version of the present paper.

Under the assumption that the simulation exercise is correct, I move next to an examination of how fiscal multipliers are affect by the presence of intermediation costs.

### 3.3 Present Value Multipliers

Multipliers serve as a valuable summary statistic when comparing fiscal effects in different models. In this section I compute the present value spending multipliers of the simulations in the previous section at various horizons to gauge the direction and magnitude of effect that costly loan production has on macro dynamics.
To compute present value multipliers, I use the following formula as provided in Leeper et al. (2011).

\[
PVM(k) = \frac{E_t\{\sum_{j=0}^{k} (\prod_{s=0}^{j} r_{t+s})^{-1} \Delta Y_{t+j}\}}{E_t\{\sum_{j=0}^{k} (\prod_{s=0}^{j} r_{t+s})^{-1} \Delta G_{t+j}\}}
\]

Here \(\Delta X_t\) represents the level deviation from steady state of variable \(X_t\), \(k\) is the horizon over which to compute the multiplier, and \(r_t\) is the gross real interest rate faced by depositors realized at time \(t\). It is worth pointing out before jumping to the results that there is not total agreement on precisely how one should compute fiscal multipliers. For instance, some look at just impact multipliers while others\(^9\) choose to discount a sequence of spending outcomes using steady state real interest rates. The virtue of present value multipliers which is missed by other approaches is that they simultaneously capture the effects on the sequence of private choices of an entire sequence of anticipated stimulus, the actual sequence of stimulus, and the correct model specific intertemporal pricing implied by utility maximizing agents.

Table 3: Present Value Multipliers from 1% increase in government consumption

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>0.5471</td>
<td>0.5880</td>
</tr>
<tr>
<td>4</td>
<td>0.3041</td>
<td>0.3614</td>
</tr>
<tr>
<td>8</td>
<td>0.0070</td>
<td>0.0854</td>
</tr>
<tr>
<td>12</td>
<td>-0.2446</td>
<td>-0.1379</td>
</tr>
<tr>
<td>24</td>
<td>-0.7181</td>
<td>-0.5113</td>
</tr>
<tr>
<td>48</td>
<td>-0.9712</td>
<td>-0.6562</td>
</tr>
</tbody>
</table>

Table 3 includes the multipliers. It should be noted that I am not taking seriously the magnitude of any particular multiplier here. This is because I am knowingly leaving out frictions that have been shown to fit real world data where a standard RBC model has fallen short. Instead, in isolating the effect of the financial frictions in this model, I am interested in how the multiplier changes between models.

What one sees is that the full model including costly intermediation produces uniformly lower multipliers than in the model without costly intermediation. This result follows the sentiment of Goodfriend and\(^9\) Notably Harold Uhlig.
McCallum (2007). Since investment is a driver of output, intermediation costs lead to even higher real rates of interest that must be repaid on investment loans in the former model relative to the latter. Thus, less capital is produced.

4 Wrapping Up and Continuing Work

The type of intermediation cost posited by Curdia and Woodford (2010) appears to have a relatively small impact on model dynamics. Their motivation was that monetary policy might operate better by responding to credit spreads. While they claim that a Taylor rule should be modified to respond to spreads, it is important to think about why these spreads exist. In this sense I think the financial accelerator model provides a more meaningful interpretation of spreads. This being said, spreads are an indication of the cost of external funds to a company undertaking investment in capital projects. What this paper does is place focus on how the need to finance growth can provide a channel through which monetary and fiscal interactions play out to produce inflation and cost of borrowing outcomes. Understanding how policy affects borrowing costs in this way provides more substance to the optimal policy literature precisely because policy interactions may change the investment environment.

Future versions of this paper will undergo substantial revision as there are a number of exercises that I am planning to gain a deeper understanding of the role of the finance constraint in monetary-fiscal policy interactions. Among these will be an attempt to derive analytics for the model under the assumption of lump-sum taxation as a benchmark. As dynamics are decoupled given the determinacy regions from section 3.1, I will also attempt to derive analytically how the tax elasticities depend on the finance constraint. I suspect the leverage parameter $\mu$ will play a role. Further, we know how the fiscal theory operates in a simple representative agent framework, but, provided the intuition from my simulations, understanding precisely how the leakage of backing issue affects standard FTPL results is high on the priority list as well. One way to get at this is via further simulation as suggested in the body of the paper.
Appendix

Model Derivations

Depositors

\[
\max_{c_t, n_t, s_t} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) \right\}
\]

s.t. \( c_t + s_t = (1 - \tau_d) w_t n_t + \frac{R_{t-1}}{\pi_t} s_{t-1} \) \hfill (20)

\text{FOC}

\[
\begin{align*}
\frac{\partial}{\partial c_t} : U_c(c_t, n_t) &= \lambda_t^d \\
\frac{\partial}{\partial n_t} : -U_n(c_t, n_t) &= \lambda_t^d w_t \\
\frac{\partial}{\partial s_t} : \lambda_t^n &= \beta E_t \left\{ \frac{\lambda_{t+1}^d R_t}{\pi_{t+1}} \right\}
\end{align*}
\]

\[
\begin{align*}
-\frac{U_n(c_t, n_t)}{U_c(c_t, n_t)} &= w_t \quad \text{(21)} \\
1 &= \beta E_t \left\{ \frac{U_c(c_{t+1}, n_{t+1})}{U_c(c_t, n_t)} \frac{R_t}{\pi_{t+1}} \right\} \quad \text{(22)}
\end{align*}
\]

Investors

\[
\max_{c_t, l_t, n_t, k_t} E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, n_t) \right\}
\]

s.t. \( c_t + l_t + \frac{R_{t-1}}{\pi_t} l_{t-1} = (1 - \tau_l^i) w_t n_t + l_t + (1 - \tau_k^i) R_t k_{t-1} \) \hfill (23)

\((1 - \mu) k_t \leq l_t \) \hfill (24)

The borrowing constraint will always bind so we can sub out \( l_t \) and maximize subject to the budget

\[
c_t + \mu k_t = (1 - \tau_i^t) w_t n_t + \left[ (1 - \tau_k^i) R_t k_{t-1} - (1 - \mu) \frac{R_{t-1}}{\pi_t} \right] k_{t-1} \quad \text{(25)}
\]
\[ \frac{\partial}{\partial c_t^i} : U_c(c_t^i, n_t) = \lambda_t^i \]
\[ \frac{\partial}{\partial n_t^i} : -U_n(c_t^i, n_t^i) = \lambda_t^i w_t^i(1 - \tau_t^i) \]
\[ \frac{\partial}{\partial k_t} : \mu \lambda_t^i = \beta E_t \left\{ \lambda_{t+1}^i \left[ (1 - \tau_{t+1}^k) R_{t+1}^k - (1 - \mu) \frac{R_t^i}{\sigma_{t+1}} \right] \right\} \]

\[ -U_a(c_t^i, n_t^i) = (1 - \tau_t^i) w_t^i \]
\[ 1 = \beta E_t \left\{ \frac{U_c(c_{t+1}^i, n_{t+1}^i)}{U_c(c_t^i, n_t^i)} \left[ (1 - \tau_{t+1}^k) R_{t+1}^k - (1 - \mu) \frac{R_t^i}{\sigma_{t+1}} \right] \right\} \]

Financial Intermediary

\[ V(\ell, d; \varepsilon) = \max_{\ell', d'} \left\{ d' + \frac{R^l}{\pi} \ell - \left( \ell' + g(\ell'; \varepsilon) + \frac{R^d}{\pi} d' \right) + E \left\{ \frac{V(\ell, d'; \varepsilon')}{(R^d)^{\pi'}} \right\} \right\} \]

FOC

\[ 1 - \frac{R^d}{\pi} + E \left\{ \frac{V(\ell', d'; \varepsilon')}{(R^d)^{\pi'}} \right\} = 0 \]
\[ \frac{R^l}{\pi} - (1 + g_1(\ell'; \varepsilon)) + E \left\{ \frac{V_1(\ell', d'; \varepsilon')}{(R^d)^{\pi'}} \right\} \]
\[ V_1(\ell, d; \varepsilon) = \frac{R^l}{\pi} \]
\[ V_2(\ell, d; \varepsilon) = -\frac{R^d}{\pi} \]

\[ R_t^l = (1 + g_1(\ell_t; \varepsilon)) R_t \]

Following Curdia and Woodford (2010) I will set \( g_1(\cdot) = A_{l_t}^{10} \)

Firms

\[ \max_{n_t^l, n_t^d, k_{t-1}} A_t[(A_t^i n_t^i)^{\omega}(A_t^d n_t^d)^{1-\omega}]^{1-\alpha} [A_t^k k_{t-1}]^{\alpha} - w_t^i n_t^i - w_t^d n_t^d - R_t^k k_{t-1} \]
\[ w^i_t = \omega (1 - \alpha) \frac{Y_t}{n_t^i} \quad (29) \]
\[ w^d_t = (1 - \omega)(1 - \alpha) \frac{Y_t}{n_t^d} \quad (30) \]
\[ R_t^k = \alpha \frac{Y_t}{k_{t-1}} \quad (31) \]
\[ Y_t = A_t [(A^i_t n_t^i)^{\omega} (A^d_t n_t^d)^{1-\omega}]^{1-\alpha} [A^k_t k_{t-1}]^\alpha \quad (32) \]
Linearized Model

Suppose $U(c^j, n^j) = \frac{(c^j)^{1-\sigma_j}}{1-\sigma_j} - x_j \frac{(n^j)^{1+\sigma_j}}{1+\sigma_j}$ and $g_t(l_t; A_t) = A_t^l l^\theta_t$. This implies the following linearized system.

**Savers**

\[
\begin{align*}
\frac{1}{\phi_d} \tilde{n}_d^d + \sigma_d \tilde{c}_d^d &= \tilde{w}_d^d - \frac{\tau_d^d}{1-\tau_d^d} \tilde{z}_d^d \\
\sigma_d \tilde{c}_d^d &= \sigma_d E_t \{\tilde{c}_{t+1}\} - (\tilde{R}_t - E_t \{\tilde{n}_{t+1}\}) \\
C^d \tilde{c}_d^d + S \tilde{s}_t &= (1-\tau^d)W^dN^d[\tilde{w}_d^d + \tilde{n}_d^d - \frac{\tau_d^d}{1-\tau_d^d} \tilde{z}_d^d] + \frac{R}{\pi} S[\tilde{R}_{t-1} + \tilde{s}_{t-1} - \tilde{\pi}_t]
\end{align*}
\]

**Investors**

\[
\begin{align*}
\frac{1}{\phi_i} \tilde{n}_i^i + \sigma_i \tilde{c}_i^i &= \tilde{w}_i^i - \frac{\tau_i^i}{1-\tau_i^i} \tilde{z}_i^i \\
\sigma_i \tilde{c}_i^i &= \sigma_i E_t \{\tilde{c}_{i+1}\} - \frac{\beta}{\mu}(1-\tau^k)R^k \left[ E_t \{\tilde{R}_{t}^k \} - \frac{\tau_k^k}{1-\tau_k^k} E_t \{\tilde{\pi}_{t+1}^k \} \right] + (1-\mu) \frac{\beta}{\mu} \frac{R^l}{\pi} \left[ \tilde{R}_t^l - E_t \{\tilde{\pi}_{t+1}^l \} \right] \\
C^i \tilde{c}_i^i + \mu K \tilde{k}_t &= (1-\tau^i)W^iN^i[\tilde{w}_i^i + \tilde{n}_i^i - \frac{\tau_i^i}{1-\tau_i^i} \tilde{z}_i^i] + \left( \frac{\beta}{\mu} \right)^{-1} K \tilde{k}_{t-1} \\
&+ (1-\tau^k)R^k K \left[ \tilde{R}_t^k - \frac{\tau_k^k}{1-\tau_k^k} \tilde{\pi}_t^k \right] - (1-\mu) \frac{R^l}{\pi} K \left[ \tilde{R}_{t-1}^l - \tilde{\pi}_t^l \right]
\end{align*}
\]

**Production Technology**

\[
\begin{align*}
\tilde{y}_t &= \tilde{a}_t + \omega(1-\alpha)[\tilde{a}_t + \tilde{n}_t^d] + (1-\omega)(1-\alpha)[\tilde{a}_t + \tilde{n}_t^i] + \alpha[\tilde{a}_t^k + \tilde{k}_{t-1}] \\
\tilde{w}_t^d &= \tilde{y}_t - \tilde{n}_t^d \\
\tilde{w}_t^i &= \tilde{y}_t - \tilde{n}_t^i \\
\tilde{R}_t^i &= \tilde{y}_t - \tilde{k}_{t-1}
\end{align*}
\]

**Lending Technology**

\[
\begin{align*}
\tilde{R}_t^l &= \tilde{R}_t + \frac{A^l L^\theta}{1 + A^l L^\theta} [\tilde{a}_t^l + \theta \tilde{k}_t] \\
S \tilde{s}_t &= B \tilde{b}_t + (1-\mu) K \tilde{k}_t
\end{align*}
\]
Government

\[ \tilde{R}_t = \phi_t \tilde{\pi}_t + \epsilon_t^R \]  
(45)

\[ \tilde{\gamma}_t = \rho_t \tilde{\gamma}_{t-1} + \epsilon_t^\gamma \]  
(46)

\[ \tilde{z}_t^d = \gamma_d \tilde{b}_{t-1} - \tilde{y}_t + \epsilon_t^d \]  
(47)

\[ \tilde{z}_t^i = \gamma_i \tilde{b}_{t-1} - \tilde{y}_t + \epsilon_t^i \]  
(48)

\[ \tilde{z}_t^k = \gamma_k \tilde{b}_{t-1} - \tilde{y}_t + \epsilon_t^k \]  
(49)

\[ G\tilde{y}_t + \frac{R}{\pi} B[\tilde{R}_{t-1} + \tilde{b}_{t-1} - \tilde{\pi}_t] = \tau^k R^k K[\tilde{\tau}^k + \tilde{R}_t + \tilde{b}_{t-1}]... \]  
(50)

Productivity

\[ \tilde{\alpha}_t = \rho_t \tilde{\alpha}_{t-1} + \epsilon_t^\alpha \]  
(51)

\[ \tilde{\alpha}_t^d = \rho_t^d \tilde{\alpha}_t^d_{t-1} + \epsilon_t^{\alpha,d} \]  
(52)

\[ \tilde{\alpha}_t^i = \rho_t^i \tilde{\alpha}_t^i_{t-1} + \epsilon_t^{\alpha,i} \]  
(53)

\[ \tilde{\alpha}_t^k = \rho_t^k \tilde{\alpha}_t^k_{t-1} + \epsilon_t^{\alpha,k} \]  
(54)

\[ \tilde{\alpha}_t^l = \rho_t^l \tilde{\alpha}_t^l_{t-1} + \epsilon_t^{\alpha,l} \]  
(55)
References


