Regulating Over the Counter Financial Markets: Implications for the Central Bank’s Dual Mandate

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Abstract

This paper examines how financial regulation, monetary and fiscal policies interact and jointly affect the dual mandate of the central bank. Agents obtain liquidity services by trading in over the counter (OTC) financial markets where private and public liabilities are used as collateral. All policies directly impact the behavior of firms who intimately link labor and asset markets by hiring workers and issuing equity. As a result, traditional policy prescriptions to stabilize the economy in frictionless financial and labor markets are not robust to decentralized labor and financial markets.

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1 Introduction

In 1977 the United States Congress amended the 1913 Federal Reserve Act establishing a “dual mandate” for the central bank to maintain stable prices and full employment. This amendment is not only explicitly stating two distinct objectives but also highlights the importance of the underlying links between these two goals. The relative importance of these two objectives has changed over time depending on the economic conditions faced by central bankers. In 2007, during the onset of the global financial crisis (GFC), unemployment quickly rose and core inflation dramatically dropped. In response to these macroeconomic conditions, the U.S. Federal Reserve System aggressively eased monetary policy by lowering the federal funds and carried out unconventional monetary policies as to provide further accommodation, stabilize financial markets and reduce unemployment.

Since the GFC traditional policy analysis in frictionless financial markets have come into question. Subsequently the literature has been trying to identify the most relevant financial frictions and analyze the implications for policy design. There is some consensus that private provision of liquidity, collateralized

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1During the Volcker era the main priority was lowering inflation even if it was at the expense of rising unemployment. On the other hand, Greenspan tried to achieve low and stable inflation. To achieve the goals of the dual mandate, the main policy tool used has been the manipulation of the federal funds target by purchasing and selling of U.S. Treasuries. However, these traditional operating procedures for monetary policy changed after the global financial crisis (GFC).

2To implement these policies the central bank has been increasingly intervening in financial markets through the purchase and sale of public and private assets and closely monitoring its effects on unemployment. The Committee has provided guidance in the statement about how it would conduct monetary policy: “In setting monetary policy, the Committee seeks to mitigate deviations of inflation from its longer-run goal and deviations of employment from the Committee’s assessments of its maximum level. These objectives are generally complementary. However, under circumstances in which the Committee judges that the objectives are not complementary, it follows a balanced approach in promoting them, taking into account the magnitude of the deviations and the potentially different time horizons over which employment and inflation are projected to return to levels judged consistent with its mandate.” Federal Open Market Committee, January 2012, 2013, and 2014.

3We refer to Leeper and Nason (2014) for a discussion of interactions between financial stability and monetary policy in environments with frictional financial markets.
debt obligations, and the subsequent trading in over the counter (OTC) financial markets as being major
collectors to the GFC.\textsuperscript{4} These OTC financial markets have been growing over the last three decades and
have been mainly unregulated.\textsuperscript{5} During the onset of the GFC, financial markets with centralized trading
functioned rather well when compared to OTC markets. In particular, in OTC markets collateralized debt
obligations, asset and mortgage backed securities were traded only sporadically or not at all.\textsuperscript{6} Thus it is
not surprising that authorities around the world have sought to oversee the functioning of these markets
and provide them with adequate liquidity.\textsuperscript{7} These policies have been enacted while monetary and fiscal
authorities are also trying to deal with unemployment pressures.\textsuperscript{8} In this paper we analyze the impact of
such policies.

OTC financial markets are decentralized, trade is bilateral, prices and quantities are negotiated, traded
products do not have to be standardized and traders can withdraw from the market at any time.\textsuperscript{9} These
features are in sharp contrast from those observed in centralized financial exchanges. This different financial
architecture is likely to change the effects of traditional monetary and fiscal policies explored in centralized
financial markets. This paper tries to identify these differences and analyze the interactions between OTC
regulation and monetary and fiscal policies. To determine how financial regulation affects the central bank’s
dual mandate, we consider a frictional environment that builds on Rocheteau and Rodriguez-Lopez (2014).
These authors consider an environment with unemployment and where public and private assets are traded
in OTC markets. They find that when unemployment is inefficiently high and agents have access to real
bonds, it is optimal to keep liquidity scarce to lower interest rates and promote job creation. Building
on these insights, this paper considers nominal government bonds and studies how all government policies
(macroeconomic, monetary and fiscal) interact with each other and affect inflation, unemployment and
interest rate spreads. To explicitly capture the key objectives of the dual mandate, the underlying envi-
ronment has a labor market \textit{a la} Mortensen and Pissarides (1994) so that unemployment is an equilibrium
outcome. To incorporate OTC financial markets, we consider a financial market \textit{a la} Duffie, Garleanu, and
Pedersen (2005), where trades by private firms are collateralized with private and public assets. This struc-
ture allows us to explicitly analyze the inherent links between liquidity and unemployment. In particular,
we can examine how the private provision of liquidity is affected by government policies that regulate financial
markets, specify tax liabilities and the evolution of the money supply. This frictional environment delivers
an endogenous interest rate that critically depends on labor market conditions, a key aspect not previously
emphasized. As noted by Friedman (1956), Tobin (1961) and Brunner and Meltzer (1972), the equilibrium
price level is determined by the valuation of all assets jointly which emphasizes the importance of the notion
of asset liquidity. These different asset liquidity properties critically depend on the underlying frictions and
the financial architecture where these assets are traded.

Once OTC financial markets and unemployment are explicitly taken into account, the supply of liquidity
–all public and private assets– matters for the equilibrium interest rate spreads as well as the dynamics of

\textsuperscript{4}We refer more the reader to Brunnermeier (2009) and Gorton and Metrick (2012a) for discussions on the main contributors
to the GFC.

\textsuperscript{5}According to the Bank for International Settlements, the total notional amount (measure of market activity) of all the
outstanding positions at the end of June 2004 stood at $220 trillion. By the end of 2007 this figure had risen to $596 trillion,
in 2009 was $615 trillion and by June 2013 rose to $693 trillion. Relative to other financial markets, the interest rate, foreign
exchange and equity derivatives, in December 2011, accounted over 90% of all trading.

\textsuperscript{6}We refer to Gorton and Metrick (2012) for an analysis of the different financial markets during the GFC.

\textsuperscript{7}On July 21, 2010, the Dodd-Frank Wall Street Reform and Consumer Protection Act was signed into law. Key provisions
of the legislation –including clearing, trading, capital, margining, reporting and record-keeping requirements –are going to
fundamentally alter the OTC derivatives market. Under Title VII of the the Dodd-Frank Act, swap dealers and major swap
participants are subject to capital and margin requirements. The law requires initial and variation margin (also referred to as
collateral posting) for all OTC derivatives that are not cleared.

\textsuperscript{8}Yellen (2014) has stressed the importance of considering a variety of measures for assessing short and long run employment
and unemployment when designing and thinking about monetary policy.

\textsuperscript{9}The specific terms of trade are not necessarily made public to all market participants
prices, debt and unemployment. Assets in this frictional economy serve a role as a store of value and a settlement object in financial markets. This is a direct consequence of the underlying frictions that prevent trading of complete state contingent claims, thus generating a demand for liquidity. Unemployment and the private and public provision of liabilities are affected by financial regulation and fiscal and monetary policies. This is the case as all government policies directly impact the behavior of firms who intimately link labor and asset markets by hiring workers and issuing equity. In particular, government policies affect the ability of firms to hire workers and make profits. As a result, the value of assets and their liquidity properties as well as the equilibrium unemployment rate are intimately shaped by all government policies. Moreover, there is an expectational channel through which government policies (financial, monetary and fiscal) affect the equilibrium price level. This is the case as they change expected returns to both nominal and real assets. Thus the evolution of nominal prices critically depend on the dynamic interactions between current and expected future government policies.

Once decentralized labor and financial markets are taken into account non-advalorem taxes become distortionary as they affect the entry decisions of firms. Moreover, depending whether the various OTC collateral constraints bind or nor, different notions of liquidity exist which yield vastly different equilibrium properties. As a result, traditional policy prescriptions to stabilize the economy in frictionless financial and labor markets are not robust to decentralized and frictional labor and financial markets. This is the case even when firms are not taxed so that non ad-valorem taxes are pure lump sum. Thus we can conclude that the nature of the stabilization policies critically depend on the equilibrium notion of liquidity which is shaped by all government policies. By considering alternative approaches to modelling financial markets (that emphasize different frictions) and unemployment, this paper tries to improve our understanding of the inherent links between the goals of the dual mandate and how they change with financial regulation.

2 Related Literature

Since the GFC the literature has studied how various government policies affect the economy when financial frictions in centralized exchanges are present. Departures from complete financial markets are abundant and complex which emphasize different financial frictions. Some of these departures include asymmetric information, liquidity constraints, moral hazard, costly state verification and pecuniary externalities just to name a few frictions. Even though substantial progress has been made in understanding how financial frictions affects on the macroeconomy, much less attention has been devoted to the study of policy interactions in frictional financial markets with unemployment. Notable exceptions are the various works that have analyze the dual mandate of the central bank under different liquidity notions. The early contribution of Cooley and Quadrini (2004) studies optimal monetary policy in a model that integrates the search theory of unemployment with firms facing cash-in-advance constraints to purchase intermediate inputs. These authors show that when the economy is subject to productivity shocks, the optimal policy is procyclical, and with commitment, the optimal inflation rate is inversely related to the bargaining power of workers. Within a cashless framework with nominal bonds, Ravenna and Walsh (2012) consider a frictional labor market and show that when wages are rigid and fixed, the optimal tax correcting for inefficient hiring is small but very volatile over the business cycle. Gains from deviating from price stability are larger in economies with more volatile labor flows. Building on this framework, Arseneau and Chugh (2012) consider a calibrated matching model that generates empirically relevant labor-market fluctuations conditional on exogenous fiscal policy.

We refer to Quadrini (2011) and Brunnermeier, Eisenbach and Sannikov (2013) for a recent survey of the literature that deals with macroeconomics and financial frictions.

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The authors find that tax volatility induces dramatically smaller, but efficient, fluctuations of labor markets by keeping distortions constant over the business cycle. Once financial markets are incomplete so that fiat money has a role, Berentsen et al. (2007) show that the same frictions that give fiat money a positive value generate an inefficient quantity of goods in each trade and an inefficient number of trades. The Friedman rule eliminates the first inefficiency and the Hosios rule the second. Finally, Gomis-Porqueras et al (2013) show how a production subsidy in frictional goods market and a vacancy subsidy, financed by a dividend tax, can achieve efficiency even when the Hosios condition does not hold.

Even though the previous literature has explored how monetary and fiscal policies affect the dual mandate of the central bank, much less work has been focused on the private provision of liquidity for OTC markets and its subsequent impact on nominal prices and unemployment. This paper complements the previous literature by exploring the channels through which policies affect the economy when agents trade public and private liabilities in OTC markets and households face unemployment.

3 Environment

We build on Rocheteau and Rodriguez-Lopez (2014). Time is continuous where three types of private agents (a large measure of workers, a large measure of firms and a unit measure of OTC-traders) participate in goods, labor and financial OTC markets. Other than these private agents, there is a government that needs to finance some exogenous expenditures through non ad-valorem taxes, levied to all private agents, and the issuance of fiat money and nominal bonds.

Workers and firms participate in a frictional labor market a la Mortensen and Pissarides (1994). In this market workers sell their time in exchange for a wage when producing a perishable numéraire good that is consumed by all private agents. Firms in order to finance their wage bill issue and sell their securities to financial market participants. These claims to firms’ profits can be used as collateral in decentralized and frictional OTC markets. Other than this private provision of liquidity, public liabilities can also be used as collateral in these financial markets as in Duffie, Garleanu and Pedersen (2005).

In contrast to other of private agents, OTC-traders can produce and consume the numéraire good and produce and consume a perishable financial service which only they value. In order to generate a role for liquidity, the underlying economic environment has to have some frictions. In this environment, OTC-traders lack commitment (so credit can not be used as a means of payment) and the technology to consume/produce the numéraire good available to OTC-traders is not always available. The lack of commitment, the technological restriction and the fact that the numéraire good is perishable generates a need for OTC-traders to accumulate liquid assets. Traders’ portfolio is comprised of three assets: fiat money, nominal bonds and private securities. These assets serve as a store of value as well as settlement object in OTC transactions. The degree of substitution between private and public asset is affected by government policies. It is important to highlight that when there is no provision of private liquidity, the potential impact of government policies on the value of fiat money is limited as government bonds are nominal. Once the economy has a valued real asset that is not a perfect substitute for nominal bonds, government policies directly affect the degree of substitution between private and public assets, ultimately affecting the dynamics of prices, interest rate spreads and unemployment.

In the next subsection we describe the behavior of private agents in the economy.
3.1 Government

The government can issue fiat money and nominal bonds in order to finance exogenous government expenditures. Money is a pure fiat object as it is intrinsically useless asset that pays no dividend. On the other hand, nominal bonds are pure discount bonds that yield one unit of fiat money at a Poisson rate equal to one. The government has also an additional source of revenue via non ad-valorem taxes. These taxes are levied to active firms, employed workers and OTC-traders. The resulting government budget constraint is then given by

\[ G + \nu^m B = (1 + 2\nu)T + \nu^m \mathcal{M} + \nu^b \mathcal{B} \]

where \( G \) are exogenous government expenditures, \( \mathcal{M} \) is the monetary base, \( \mathcal{B} \) represents nominal bonds, \( \nu^m (\nu^b) \) denotes the real value of a unit of fiat money (a nominal bond) in terms of the numéraire good, \( T \) represents the non ad-valorem tax and \( 2\nu \) is the measure of active firms and workers. Notice that even though taxes to private agents are non ad-valorem they do affect the entry decision of firms. This effect is not observed in frictionless Walrasian environments where non ad-valorem taxes are always lump sum.

In this environment, government policies change the tax base which critically affects the beliefs regarding future nominal prices and the fiscal backing of nominal bonds.

Following the spirit of the 2010 Dodd-Frank Act, we consider regulation in OTC financial markets that restrict the set of securities that can be used as collateral when trading in OTC financial markets. Public liabilities are considered more safe and liquid than private ones. Among public liabilities, fiat money is universally accepted and government bonds have a role as collateral in financial trades. Thus, for a fraction \( \mu^m \) of matches only fiat money is acceptable, and in a fraction \( \mu^b \) of matches fiat money and government bonds can only be used to settle OTC trades. In the remaining fraction of matches, \( \mu^p = 1 - \mu^m - \mu^b \), all public and private assets are acceptable. These collateral requirements influence the value of the various assets in the economy.

To describe the particulars of fiscal policies, we follow those suggested by the proponents of the Fiscal Theory of the Price Level (FTPL). Consistent with the FTPL and the current fiscal reality, the fiscal authority chooses a fiscal rule whereby taxes depends on the quantity of real government debt so that:

\[ \tau = \eta_0 + \eta_1 \nu^b \mathcal{B}, \]

where \( \eta_0 (\eta_1) \) are constant policy parameters.

For the operating procedure for monetary policy, we consider a constant money growth rate, \( \pi \), rule so

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11The Dodd-Frank Act of 2010 requires a larger fraction of derivatives transactions to be cleared in centralized exchanges with higher collateral requirements.

12This is in the spirit of Woodford (1990).

13We refer to Rocheteau and Rodriguez-Lopez (2014) for the macroprudential interpretation and other alternative interpretations.

14As in Canzoneri and Diba (2005), government bonds can also provide liquidity services. In this environment, private claims can also provide such services.

15The Fiscal Theory of the Price Level (FTPL) was developed primarily by Leeper (1991), Sims (1994), Woodford (1994) and Cochrane (2001). This literature emphasizes that bonds are denominated in nominal terms so that they may be fully backed by real resources or backed only by nominal cash flows. Thus it is possible for fiscal policies to stabilize the price level. This fiscal result is robust to different monetary and cashless environments with centralized financial markets. As in Leeper’s (1991) money in the utility function model or Woodford’s (1998) cashless economy. For more details, we refer to Canzoneri et al (2011) who provide a recent survey of the findings in the FTPL.

16According to the IMF, in early 2009 there were 80 countries with national and/or supranational fiscal rules: 21 advanced, 33 emerging markets, and 26 low-income countries. In contrast, in 1990, only seven countries had fiscal rules. Some consensus has emerged among policymakers about the desirability of fiscal rules to help deter fiscal crises and facilitate implementing more countercyclical fiscal policies. The use of a debt sustainability framework (see Ghosh et al. (2011) and the references therein) is commonly used for policy analysis as emphasized by IMF Article IV country reports.

17We abstract from fiscal rules enforcement issues and focus on the effects that a fiscal rule would have if the government could commit to enforce it.
that the money supply evolves according to $\dot{M} = \pi M$. We follow this rule as this economy delivers interest rate spreads. In such an environment it is not clear which interest rate should be used when considering a Taylor rule. In this paper we sidestep this interesting issue.

It is convenient to write the government budget constraint in terms of real government liabilities which is given by

$$\dot{m} + \dot{b} = G + \nu^m m + \left( \frac{\nu^m}{\nu^b} + \nu^b \right) b - (1 + 2n)T$$

where $m = \nu^m M$ represents real balances and $b = \nu^b B$ denotes real bonds.

### 3.2 Workers and Firms

Workers are endowed with one indivisible unit of labor per unit of time. They are risk-neutral and they discount future consumption at rate $\rho > 0$. Thus their lifetime expected utility is given by

$$\mathbb{E} \int_0^\infty e^{-\rho t} dC(t)$$

where $C(t)$ is their cumulative net consumption of the numéraire good and $\mathbb{E}$ is the expectation operator.

Each firm can be thought as a technology that produces the numéraire good using a worker’s indivisible labor as input. As in Mortensen and Pissarides (1994), workers and firms are matched bilaterally. The flow of hires is equal to $h(u, v)$, where $u$ denotes the measure of unemployed workers and $v$ represents the measure of vacancies. The matching function, $h(\cdot, \cdot)$, has constant returns to scale, is strictly concave with respect to each of its arguments, and satisfies Inada conditions. Given this matching function the job finding rate of a worker is $p(\theta) \equiv h(u, v)/u = h(1, \theta)$ where $\theta = v/u$ represents the labor market tightness. Similarly, the vacancy filling rate is $q(\theta) \equiv h(u, v)/v = h(\theta^{-1}, 1)$.

Each successful match, of a worker and a firm, produces a constant flow of numéraire output equal to $\Phi$. Thus after paying taxes, the resources available to a firm are $\Phi - T > 0$. A match is exogenously destroyed with a Poisson arrival rate of $\delta > 0$. The wage of an employed worker is $w$ and without loss in generality we set the income of the unemployed to zero.

In order to fill a job a firm must open a vacancy which has associated a cost flow in terms of the numéraire good equal to $\gamma > 0$. Firm’s recruiting expenses are paid by OTC-traders in exchange for claims to their future profits which can then securitize.\(^\text{18}\) Claims on firms’ revenue are not subject to informational asymmetries and they can be partially used as collateral in $\mu^p$ of the OTC trades as dictated by the macroprudential policy. The rate of return of a share of a firm is denoted $r$.

New firms are financed as long as the flow cost of opening a vacancy, $\gamma$, is no greater than the flow expected value of a vacancy, which is the product of the vacancy filling rate and the value of a filled job, $q(\theta)V_F$. Free entry then implies that

$$\gamma = q(\theta)V_F$$

and the total supply of private liquidity corresponds to the total capitalization of firms which is given by

$$L^p = n V_F.$$

\(^{18}\)Securitization is a process in which different assets or portfolios of cash flow generating securities are pooled together and then sold to third parties.
The resulting value of a filled job solves the following Bellman equation
\[ rV_F = \Phi - \mathcal{T} - w - \delta V_F + \dot{V}_F \] (4)
while the law of motion for employment is given by
\[ \dot{n} = p(\theta)(1 - n) - \delta n. \] (5)

As we can see, non ad-valorem taxes, \( \mathcal{T} \), on active firms affect the value of the firm which in turn changes their entry decision. In this environment, fiscal policy not only directly affects the tax base but also the supply of private liquid claims that compete with public liabilities in OTC financial markets. Finally, we note that the firm is key in that links the labor and financial market by hiring workers and supplying assets.

### 3.3 OTC-traders

OTC-traders derive linear utility from the numéraire good, which they can consume and produce, and from a perishable financial service. In order to derive utility from financial services they need to accumulate different assets that can be traded in the frictional financial market. These agents exchange financial services in an OTC market as in Duffie, Garleanu and Pedersen (2005). This frictional and decentralized financial market is characterized by bilateral matching and bargaining. The lifetime expected utility of an OTC trader is then given by
\[
E \left[ \sum_{n=1}^{\infty} e^{-\rho T_n} \left[ f(y(T_n)) - x(T_n) \right] + \int_0^{\infty} e^{-\rho t} dC(t) \right],
\]
where the first term represents the utility associated with OTC trades, while the second terms denotes the utility from net consumption of the numéraire good. \( T_n \) represents a Poisson process with arrival rate \( \beta > 0 \), indicating the times at which the trader is matched bilaterally with another trader. OTC-traders can not produce the numéraire when \( t \in \{T_n\}_{n=1}^{\infty} \). OTC financial services could be settled with a loan to be repaid after the match. However, given that unsecured loans are not credible due to a lack of commitment and that OTC-traders can not always produce the numéraire good to purchase financial services, there is a demand for public and private assets. Thus the loan issued by an OTC-trader is always secured with some collateral.\(^\text{19}\) It is important to note that since workers are risk-neutral (no need for consumption smoothing), the demand for liquid assets is entirely driven by OTC-traders.

Upon a bilateral match being formed, a trader is chosen at random, with equal probability, to be either a supplier or a user of financial services. The utility from consuming \( y \) units of financial services is \( f(y) \), where \( f(\cdot) \) is strictly concave while the disutility from producing \( x \) units of financial financial services is \( x \). The exact terms of trade in this OTC financial market are determined by a buyer take it or leave it offer. A contract in the OTC market is then a pair, \( (y,d) \) that specifies a production of services, \( y \), in exchange for a transfer of assets, \( d \). This could also be interpreted as a market where the buyer is paying with assets so that the trade is final. Alternatively, it can be viewed as a collateralized loan where the buyer promises to repay \( d \) units of numéraire as soon as he exits the OTC market, and the repayment of the loan is secured by the deposit of \( d \) units of liquid assets.

The problem of the OTC trader with an initial portfolio of real money balances, real bonds and private

\(^{19}\)When buying assets from firms, OTC-traders can fully diversify their portfolio of different equities via securitization of large pools of assets which can turn these private claims into safe and liquid assets.
assets \((m_0, g_0, a_0)\) is given by
\[
\max_{m(t), m(b(t), a(t), c(t))} \mathbb{E} \left[ \int_0^{T_1} e^{-\rho' c(t)} dt + e^{-\rho T_1} Z[m(T_1), g(T_1), a(T_1)] \right]
\]
\[
s.t. \dot{a} + \dot{m} + \dot{b} = r m + r^g b + r a - c - T
\]
where \(r^m(r^g)\) represents the return on real balances (real bonds) and \(Z(m, g, a)\) is the continuation value of an OTC trader upon being matched. This value function solves the following problem
\[
Z(m, g, a) = \frac{\mu_p^p}{2} \max_{y_p \leq m + b + a} \left[ f(y_p) - y_p \right] + \frac{\mu_g^g}{2} \max_{y_g \leq m + b} \left[ f(y_g) - y_g \right] + \frac{\mu_m^m}{2} \max_{y_m \leq m} \left[ f(y_m) - y_m \right].
\]
which captures the fact that the terms of trade are given by a buyer take it or leave it offer, that an OTC trader has equal probability to be a buyer or a seller and that not all assets can be used as collateral in all states of the world, as stipulated by the macroprudential regulation. The OTC-trader views the various assets in his portfolio as a store of value as well as a means to settle transactions. These different functions give rise to an equilibrium notion of liquidity that is shaped by all government policies.

The OTC trader’s optimal portfolio solves the following system of equations that links the return of the available assets with the liquidity needs of OTC-traders. Formally, we have that the rate of return on the various assets satisfy the following conditions
\[
\frac{\rho - r}{\sigma} = \mu^p[f'(y^p) - 1];
\]
\[
\frac{\rho - r^g}{\sigma} = \mu^g[f'(y^g) - 1];
\]
\[
\frac{\rho - r^m}{\sigma} = \mu^m[f'(y^m) - 1];
\]
where \(y^p = \min\{m + b + L^p, y^*\}, y^g = \min\{m + b, y^*\}, y^m = \min\{m, y^*\}\), \(f'(y^*) = 1\) and \(1/\sigma\) denotes the expected time before the trader receives an opportunity to purchase OTC financial services. It is important to note that value of assets are also impacted by monetary and fiscal policies as they affect the degree of substitution between these assets by altering interest rate spreads.

Private assets dominate government bonds in their rate of return \((r > r^g)\) provided that \(\mu^g > 0\) and \(y^g < y^*\). Similarly, government bonds dominate fiat money in their rate of return \((r^g > r^m)\) if \(\mu^m > 0\) and \(y^m < y^*\). Recall that since fiat money yields no dividend its rate of return is given by
\[
r^m = \frac{\dot{\nu}^m}{\nu^m}
\]
while the price of bonds solves the following asset pricing condition,
\[
r^g \nu^b = \nu^m - \nu^b + \dot{\nu}^b
\]
which rules out any arbitrage opportunity.

As noted by Friedman (1956), Tobin (1961) and Brunner and Meltzer (1972), the equilibrium price level is determined by the valuation of all assets jointly. It is also important to determine the beliefs about future inflation which are affected by current and future tax as well as financial policies.20

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20 Initially Leeper (1991) emphasized the role of expectations when just analysing monetary and fiscal policy in frictionless centralised environments.
4 Monetary Equilibrium

In this section we study the equilibrium properties of an economy with trades in OTC financial markets and in which workers face unemployment.

**Definition 1** Given some exogenous government expenditures, a constant money growth rate rule and a fiscal policy rule where taxes are linked with government debt, a monetary equilibrium is an allocation of real assets, \( \{m, b, a\} \), labor market outcomes, \( \{\theta, n\} \), goods and services, \( \{C, y\} \), as well as interest rates, \( \{r^m, r^g, r\} \), that satisfies the optimality conditions of workers, firms and OTC-traders while labor and financial markets clear.

After imposing market clearing and private agents’ optimality conditions, the resulting monetary dynamic equilibrium is given by a system of non-linear differential equations that specify the evolution of the real value of fiat money and nominal bonds, firms values, the measure of employed workers and nominal bonds. The resulting dynamic equilibrium is given by

\[
\dot{m} = m \left( \pi + \frac{\dot{\nu}^m}{\nu^m} \right)
\]

\[
r - \left[ \frac{\nu^m}{\nu^b} - 1 + \frac{\dot{\nu}^b}{\nu^b} \right] = \mu^g \sigma (f'(y^g) - 1)
\]

\[
\frac{\nu^m}{\nu^b} - 1 + \frac{\dot{\nu}^b}{\nu^b} - \frac{\dot{\nu}^m}{\nu^m} = \mu^m \sigma (f'(y^m) - 1)
\]

\[
\dot{m} + \dot{b} = G + \frac{\dot{\nu}^m}{\nu^m} m + \left( \frac{\nu^m}{\nu^b} + \frac{\dot{\nu}^b}{\nu^b} \right) b - (1 + 2n)(\eta_0 + \eta_1 b)
\]

\[
\dot{V}_F = rV_F - (\Phi - (\eta_0 + \eta_1 b) - w - \delta V_F)
\]

\[
\dot{n} = h(1, \theta)(1 - n) - \delta n
\]

where \( V_F = \frac{\gamma h}{\tilde{y} + \tilde{y} + \tilde{y}} \), \( r = \rho - \sigma \mu^g [f'(y^g) - 1] \), \( y^m = \min\{m, y^*\} \), \( y^g = \min\{m + b, y^*\} \), \( y^p = \min\{m + b + nV_F, y^*\} \) and \( f'(y^*) = 1 \). From now on, to simplify exposition, we assume specific functional forms so that the labor matching function is \( h(1, \theta) = A \theta^{1-\alpha} \) and the pay off to liquidity services is given by \( f(x) = Dx^\phi \) where \( \{\alpha, \phi\} \in (0, 1) \) and \( \{A, D\} \in (0, \infty) \).

Depending on the underlying parameters, different types of equilibria that can emerge as the various liquidity constraints may bind, determining the degree of substitution between the private and public assets. In the next sections we characterize the equilibrium where private and public liquidity provision is plentiful. We analyze two cases. One where total government liabilities, fiat money and nominal bonds alone can meet the liquidity needs of OTC-traders and one in which they can not.

5 Abundant Liquidity But Not Enough Fiat Money

In this environment fiat money alone is not sufficient to satisfy the liquidity needs of OTC-traders but all government liabilities can. As a result, the interest rate on private claims equals the rate of time preference, \( r = \rho \), and government bonds pay the same return as private liabilities so that \( r^g = r = \rho \). In this equilibrium private assets and nominal bonds are perfect substitutes as store of value. However, they are not when it comes to settling transactions in OTC financial markets unless \( \mu^g = \mu^p \). The resulting dynamic equilibrium
is given by the following system of differential equations

\[ \dot{m} = m \left( \pi + \frac{\dot{\nu}^m}{\nu^m} \right) \]
\[ \frac{\dot{\nu}^b}{\nu^b} = \rho - \left[ \frac{\nu^m}{\nu^b} - 1 \right] \]
\[ \frac{\dot{\nu}^m}{\nu^m} = \rho - \mu^m \sigma [D \phi m^{\delta-1} - 1] \]
\[ \dot{m} + \dot{b} = G + \frac{\dot{\nu}^m}{\nu^m} m + \left( \frac{\nu^m}{\nu^b} + \frac{\dot{\nu}^b}{\nu^b} \right) b - (1 + 2n)(\eta_0 + \eta_1 b) \]
\[ \dot{\theta} = \frac{\theta}{\alpha} \left[ (\rho + \delta) - (\Phi - w - (\eta_0 + \eta_1 b)) \frac{\theta^{-\alpha}}{A\gamma} \right] \]
\[ \dot{n} = \theta^{1-\alpha} (1 - n) - \delta n \]

where \( m < y^* \) and \( m + b \geq y^* \) which simply reflects the fact that private assets are not really needed to satisfy the liquidity needs of OTC-traders.

Substituting the equilibrium growth rates of the various nominal prices we have that the dynamic equilibrium is given by

\[ \dot{m} = m \left( \pi + \rho + \mu^m \sigma - \mu^m \sigma \phi D m^{\delta-1} \right) \] \hspace{1cm} (13)
\[ \dot{m} + \dot{b} = G + m \left( \rho + \mu^m \sigma - \mu^m \sigma \phi D m^{\delta-1} \right) + (1 + \rho - (1 + 2n)\eta_1) b - (1 + 2n)\eta_0 \] \hspace{1cm} (14)
\[ \dot{\theta} = \frac{\theta}{\alpha} \left[ (\rho + \delta) - (\Phi - w - (\eta_0 + \eta_1 b)) \frac{\theta^{-\alpha}}{A\gamma} \right] \] \hspace{1cm} (15)
\[ \dot{n} = \theta^{1-\alpha} (1 - n) - \delta n \] \hspace{1cm} (16)

As we can see, the evolution of new jobs and labor market tightness depend on the evolution of public liabilities and their corresponding real values. Macroprudential, monetary and fiscal policies directly affect labor market outcomes. This is the case as taxes faced by firms affect their ability to issue private claims as government a firm’s tax liability affects its entry and hiring decisions. Moreover, macroprudential and monetary policies directly affect the liquidity value of private claims as it changes their value as collateral in the OTC market. Finally, it is also important to note that in this equilibrium labor market outcomes also affect asset market dynamics. This fact simply reflects that labor market conditions, the costs of posting vacancies and the severity of labor market frictions, directly affect the value of the firm which in turn affects their private provision of liquidity.

The underlying mechanisms of the previous dynamic equilibrium are consistent with the findings of Gatti et al (2012) who show that for 18 OECD countries over the pre-crises period, 1980-2004, the impact of financial variables depend strongly on the labor market context while the impact of labor market characteristics on financial markets appears to be less significant.\(^{21}\)

\( ^{21}\) These authors show that increased market capitalization as well as decreased banking concentration reduce unemployment if the level of labour market regulation, union density, and coordination in wage bargaining is low. Increasing intermediated credit and banking concentration is beneficial for employment when the degree of labor market regulation, union density, and wage coordination is high. These results suggest that the respective virtues of intermediated and market-based finance are crucially tied to the labour market context.
Steady States

We focus on a monetary steady state where real money balances, real bonds, new employment and labor market tightness are constant over time. This implies that \( \dot{m} = \dot{b} = \dot{n} = \dot{\theta} = 0 \). After imposing the steady state conditions, we have that

\[
(\rho + \delta) \gamma^{\alpha} = \left( \varepsilon_1 - \eta_1 \frac{\varepsilon_0 + 2\eta_0 n}{1 + \rho - \eta_1 (1 + 2n)} \right) \tag{17}
\]

where \( \varepsilon_0 = \pi_{1} \nu_{m} + n_{0} - G \), \( \varepsilon_1 = \Phi - w - \eta_0 \), \( n = \Phi - w = \eta_0 \), \( \mu = 1 + \rho + \pi \), \( b = \frac{\varepsilon_0 + 2\eta_0 n}{1 + \rho - \eta_1 (1 + 2n)} \) and \( m = \left( \frac{D_{\Phi} m_{\sigma}}{\rho + \pi + \mu_{m}} \right)^{1/\gamma} \).

Next, we establish sufficient conditions for the existence of a monetary steady state. All proofs can be found in the Appendix.

Proposition 2 A monetary steady state is unique whenever the underlying parameters of the economy satisfy the following sufficient conditions

\[ \eta_0 (1 + \rho) + \eta_1 \varepsilon_0 > \eta_1 \varepsilon_0 \quad \& \quad \varepsilon_1 > \frac{\eta_1 \varepsilon_0}{1 + \rho - \eta_1} \]

Having established conditions for uniqueness of monetary steady states, we now explore its properties in terms of fiscal, monetary and macroprudential policies.\(^{22}\)

Proposition 3 Whenever the fiscal authority follows a fiscal policy such that \( \eta_1 > 1 + \rho \), then the value of the firm increases with \( \eta_0 \) and \( \mu_m \) while the value of the firm decreases with inflation, \( \pi \).

When fiscal policy is aggressive (\( \eta_1 > 1 + \rho \)) nominal bonds tend to be more abundant, making private liabilities more scarce which in turn increases the value of the firm. This finding highlights the importance of studying policy design holistically as the different policies shape the monetary equilibrium in nontrivial ways.

The importance of the labor market in policy design has been emphasized by Kocherlakota (2010), Plosser (2010) and Lacker (2012) during the onset of the financial crises. These policy markers have suggested that the high unemployment rate during the global financial crises is due to a reduction in the matching efficiency between vacant and unemployed. Consistent with the view of the importance of the labor market for monetary policy, this equilibrium has also the property that labor market conditions have important effects for the provision of both private and public liabilities. This is summarised in the following Proposition.

Proposition 4 An increase in the rate at which jobs are destroyed, in vacancy costs and in the labor matching efficiency always reduces the demand for real government bonds.

According to Proposition 4, the drop in the matching efficiency during the GFC, argued by Kocherlakota (2010), Plosser (2010) and Lacker (2012), would be associated with an increase in the demand for real government bonds. Changes in labor market conditions directly affect the tax base which can be used to finance nominal government bonds ultimately affecting its supply and the attractiveness of private assets. This is the case as the firm provides private liquidity, which is directly affected by fiscal policies, that competes with public assets in the portfolio of OTC-traders.

\(^{22}\)It is important to highlight that the steady state equilibrium has a nominal indeterminacy. As emphasized by McCallum (1986, 2001), it is important to distinguish between two different types of price level indeterminacy: nominal and non-uniqueness of dynamics paths to the steady state. Nominal indeterminacy arises when the model fails to determine nominal variables for a given path of real variables. Solution multiplicity refers to price level behaviours involving bubbles, thus an infinite number of paths for the price level and for real allocations satisfies all the conditions of the model. In this paper there can be monetary equilibria that exhibit both types of indeterminacy.
Summarizing, financial regulation \((\mu^m)\), monetary \((\pi)\) and fiscal \((\eta_0\) and \(\eta_1)\) policies affect the steady state values of real assets and labor market observables. Thus, a holistic approach to policy design should be taken into account when considering economies with frictional labor and financial markets.

**Local Dynamics**

In order to study local dynamics we need to analyze the Jacobian implied by the system of differential equations (18)-(21) that describe the monetary equilibrium. The evolution of labor market outcomes are not independent of the real value of government debt. This feature has important implications for the design of stabilization policies. The associated Jacobian evaluated is given then by

\[
J_{ss} = \begin{bmatrix}
\Omega_1 & 0 & 0 & 0 \\
-\Omega_2 & \Omega_3 & 0 & -\Omega_4 \\
0 & \Omega_5 & \Omega_6 & 0 \\
0 & 0 & \Omega_7 & -\Omega_8
\end{bmatrix}.
\]

The corresponding characteristic equation of this Jacobian is given by

\[
p(\lambda) = (\Omega_1 - \lambda)[(\Omega_3 - \lambda)(\Omega_6 - \lambda)(-\Omega_8 - \lambda) - \Omega_4\Omega_5\Omega_7];
\]

where the different elements of the Jacobian are

\[
\begin{align*}
\Omega_1 &= (1 - \phi)(\rho + \pi + \mu^m\sigma); \\
\Omega_3 &= 1 + \rho - (1 + 2n)\eta_1; \\
\Omega_4 &= 2(\eta_0 + \eta_1 b); \\
\Omega_5 &= \eta_1 \theta^{1-\alpha} \\
\Omega_6 &= \frac{\theta^{-\alpha}(\Phi - w - \eta_0 - \eta_1 b)}{A^\gamma}; \\
\Omega_7 &= (1 - \alpha)(1 - n)\theta^{-\alpha}; \\
\Omega_8 &= (\theta^{1-\alpha} + \delta);
\end{align*}
\]

where \(\theta\) is the solution to equation (17), \(b\) is the steady state real bonds and \(n\) is the steady state equilibrium employment.

Since \(\mu^m\) can only take values between zero and one, the first eigenvalue can not be negative even when we impose substantial deflation episodes. This is the case as its value is bounded by the zero lower bound; i.e, \(\pi = -\rho\). The rest of the eigenvalues depend on monetary, fiscal and macroprudential policy parameters. In particular, the steady state tax revenues and the money growth rate affect the magnitude of the eigenvalues. Finally, in general this economy is going to exhibit endogenous volatility as for generic parameter values, the monetary equilibrium will imply a cubic characteristic polynomial which typically has complex roots.

### 5.1 Importance of the Tax Base

Here we analyze the consequences of implementing fiscal policies which differentially affect the tax liabilities of firms, workers and OTC-traders. It is worth highlighting than when the fiscal authority just taxes OTC-traders, the economy displays a dichotomy between the labor and asset markets. This is the case as taxes to OTC-traders are pure lump sum as they do not affect any margins. Moreover, the effective tax base is independent of any policy action. As a result one can study the dynamic properties in two separate blocks. Thus the labor and asset markets do not affect each other. It is easy to show that in this new environment there exists a unique monetary steady state that is given by

\[
m = \left(\frac{D\phi\mu^m\sigma}{\rho + \pi + \mu^m\sigma}\right)^{\frac{1}{1-\sigma}};
\]

\[
b = \frac{\pi m + \eta_0 - G}{1 + \rho - \eta_1};
\]
with the eigenvalues associated with the asset market given by

\[ \lambda_1 = (1 - \phi) (\mu m \sigma + \rho + \pi); \quad \lambda_2 = 1 + \rho - \eta_1; \]

while the labor market eigenvalues are

\[ \lambda_3 = \rho + \delta, \quad \lambda_4 = -\left( \delta + \left( \frac{\Phi - w}{(\rho + \delta)A\gamma} \right)^{1-\alpha} \right). \]

As in the FTPL, in order for the equilibrium to be determinate, fiscal policy has to be aggressive; \( \eta_1 > 1 + \rho \).\(^{23}\) In contrast to the previous literature, search frictions in the labor and financial market as well as financial regulation affect the rate of convergence. However, financial regulation can not change the determinacy of the dynamic equilibrium.

When firms and workers are not being taxed, the resulting monetary equilibrium drastically changes relative to the case where all agents in the economy are taxed. Once the environment has several heterogenous agents and there are sunk costs, it is important to specify how taxes are collected.\(^{24}\) This is the case as the tax burden can be spread/concentrated and can alter entry decisions. These circumstances drastically change the tax base ultimately affecting the potential fiscal backing of nominal bonds. In our environment taxes on firms critically affect the effective tax base as they affect the entry decisions of firms. This in turn affects their ability to issue private claims that are valued by OTC-traders directly impacting the financial sector.

### 5.2 Quantitative Exploration

Since there is no close form solution for the steady state equilibrium, a quantitative analysis is required to determine the local determinacy properties. To evaluate the impact of macroprudential, monetary and fiscal policies we calibrate the model. In order to do so, we follow the search labor literature and closely follow Shimer (2005) who considers US data from 1951 until 2003.\(^{25}\) The unit of time represents one quarter and we set \( \rho = 0.012 \) so that the annual real interest rates is around 5%. The job destruction rate is set such that \( \delta = 0.1 \) which is consistent with Shimer’s (2005) observation that on average jobs last about two and a half years. He also estimates that job finding rates are 0.45 per month which imply a job finding rate equal to 1.35. Following Shimer (2005), we normalize labor market tightness, \( \theta = 1 \), so that the worker-finding rate is equal to the job-finding rate. Therefore, we have that \( \alpha = 0.72 \) and \( A = 1.35 \). Arseneau and Chugh (2012) find that the cost of advertising a vacancy is 3% of total firm’s output, which yields a \( \gamma = 0.03 \) when we normalize firm’s output to one so that \( \Phi = 1 \). We then set \( w = 0.7 \). For the OTC market we assume that traders become buyers at Poisson rate \( \sigma = 1 \) and liquidity services are given \( \phi = 0.25 \) and \( D = 18 \). Finally, given that neither macroprudential policies nor government spending can change the sign of the eigenvalues, we set \( \mu m = 0.3 \) and \( G = 0.1 \).

With this parametrization, we first consider an economy with mild inflations and deflations by fixing

\[ \theta = \left( \frac{\Phi - w}{A\gamma(\rho + \delta)} \right)^{1/\alpha}; \quad n = \frac{\theta^{1-\alpha}}{\theta^{1-\alpha} + \delta}; \]

\[^{23}\]As in Leeper’s (1991) money in the utility function model or Woodford’s (1998) cashless economy, a Taylor rule that responds more than one to one to inflation makes prices determinate as long as fiscal policy adjusts to stabilize government debt. In terms of policy rules, the fiscal requirement for price stability delivers an easy rule: taxes should be set to at least cover principal and interest rates on bonds.

\[^{24}\]In representative agent frameworks with non ad-valorem taxes, which is the environment typically used in the FTPL literature, there is only one household (that owns firms) that can be taxed.

\[^{25}\]We refer to Hornstein, Krusell and Violante (2005) for a detailed discussion of the calibration.
the exogenous money growth rate.\footnote{When computing equilibria we consider fiscal parameters ($\eta_0$ and $\eta_1$) such that: the different fiscal policy parameters yield steady state equilibria with positive real government liabilities; labor market outcomes are positive; profits are positive and all government liabilities are enough, but not fiat money alone, to meet the liquidity needs to OTC-traders. Table 1 reports some monetary equilibria with the corresponding fiscal parameters values, steady state asset and labor market outcomes and eigenvalues.}

When computing equilibria we consider fiscal parameters ($\eta_0$ and $\eta_1$) such that: the different fiscal policy parameters yield steady state equilibria with positive real government liabilities; labor market outcomes are positive; profits are positive and all government liabilities are enough, but not fiat money alone, to meet the liquidity needs to OTC-traders. Table 1 reports some monetary equilibria with the corresponding fiscal parameters values, steady state asset and labor market outcomes and eigenvalues.

$$
\begin{array}{|c|c|c|c|c|c|c|}
\hline
\eta_0 & 0.1 & 0.1 & -0.4 & -0.4 & -0.4 & -0.4 \\
\eta_1 & 0.29 & 0.29 & 1.012 & 1.012 & 1.012 & 1.012 \\
\pi & 0.005 & -0.005 & -0.005 & -0.005 & 0.005 & 0.005 \\
\theta & 0.0208 & 0.4209 & 5.409 & 0.8645 & 34.98 & 0.02297 \\
n & 0.7719 & 0.8870 & 0.9413 & 0.9058 & 0.9644 & 0.7766 \\
m & 6.9 & 7.201 & 7.201 & 7.201 & 6.9 & 6.9 \\
b & 0.6889 & 0.6814 & 0.6763 & 0.6876 & 0.6337 & 0.6915 \\
\lambda_1 & 0.2378 & 0.2302 & 0.2302 & 0.2302 & 0.2378 & 0.2378 \\
\lambda_2 & -1.345 & -1.067 & -2.088 & -2.088 & -2.82 & -2.683 \\
\lambda_3 & 0.6302 - i 1.079 & 0.2503 - i 0.4616 & -1.478 & -0.3463 - i 0.2282 & -1.932 & 0.369 - i 1.548 \\
\lambda_4 & 0.6302 + i 1.079 & 0.2503 - i 0.4616 & 0.07015 & -0.3463 + i 0.2282 & 0.1063 & 0.369 + i 1.548 \\
\hline
\end{array}
$$

Table 1: Equilibrium outcomes when all agents are taxed.

As we can see from Table 1, the economy is indeterminate when the economy has deflation and the fiscal authority follows a passive policy, $\eta_1 < 1 + \rho$, as in the case where OTC-traders are the only ones being taxed. Under this fiscal regime endogenous volatility is observed as there exist two complex eigenvalues. Once the fiscal authority follows an aggressive policy, $\eta_1 > 1 + \rho$, multiplicity of steady states is observed. In particular, one of the steady states is associated with a higher unemployment rate, is indeterminate and exhibits endogenous fluctuations. The other monetary steady state is determinate and has associated a lower unemployment rate and a much larger vacancy to unemployment ratio. All these properties, are observed even when fiat money is not quantitatively important in OTC financial markets; i.e, $\mu^m$ is very small. Moreover, irrespective of the fiscal stance, the specific monetary steady state values critically affect the dynamic properties of the economy. In particular, the value of $\eta_0$ in the fiscal rule affects the speed of divergence and the size of the endogenous fluctuations. These equilibrium properties are in sharp contrast to the case where OTC-traders are the only private agents being taxed.

The monetary equilibria in Table 1 clearly highlight the importance of specifying not just the tax rules but also clearly describing the economic agents that are going to be facing taxes. Even if these taxes are non ad-valorem, they affect the entry decisions of firms and the eventual fiscal backing of nominal bonds. The distortionary nature of taxing firms allows for the possibility of multiple equilibria when the fiscal authority follows an aggressive policy as the tax base responds to changes in policies. It is important to note that changes in the tax base affects the fiscal backing of bonds ultimately affecting their liquidity value. As we can see, monetary, fiscal and financial policies are intimately intertwined critically affecting the monetary steady state as well as its dynamic properties. The usual Walrasian policy prescriptions are not that informative when frictional decentralized labor and financial markets exist. This is the case as even when non-advalorem taxes are considered fiscal policies are inherently distortionary.

6 Abundant Liquidity But Not Enough Government Liabilities

We now examine an equilibrium where the sum of private and public liabilities is abundant to meet the liquidity needs of OTC-traders only when all three assets can be used as collateral. In this equilibrium
the return on government bonds is lower than the one obtained with private assets; i.e, \( r = \rho > r^g \). Thus private assets and government bonds are not perfect substitutes both as a store of value as well as settlement objects in the OTC market. The resulting dynamic equilibrium is given by

\[
\dot{M} = \pi M
\]

\[
\frac{\dot{b}}{b} = \rho - \left[ \frac{\nu^{m}}{\nu^{m}} - 1 \right] - \mu^{q} \sigma [D \phi (m + b)^{\phi - 1} - 1]
\]

\[
\frac{\dot{m}}{m} = \rho - \mu^{m} \sigma [D \phi m^{\phi - 1} - 1]
\]

\[
\nu^{b} \dot{B} = \left( \frac{\nu^{m}}{\nu^{m}} - \eta_{1} (1 + 2n) \right) \nu^{b} \eta_{0} (1 + 2n) + \dot{G} - \pi m
\]

\[
\frac{\dot{B}}{B} = \frac{1}{\alpha} \left[ (\rho + \delta) - (\Phi - w - (\eta_{0} + \eta_{1} b)) \frac{\theta^{-\alpha}}{A_{\gamma}} \right]
\]

\[
\dot{n} = \theta^{1-\alpha} (1 - n) - \delta n
\]

where \( m + b < y^{*} \) and \( m + b + \eta \gamma \theta^{\alpha} \geq y^{*} \) which simply reflects the fact that private assets are essential to satisfy the liquidity needs of OTC-traders.\(^{27}\)

The implied equilibrium notion of liquidity is then rather different from the one implied in the earlier section. This different liquidity notion will imply quite different results. Substituting the implied nominal growth rates, the equilibrium is given by

\[
\dot{m} = m \left( \pi + \rho + \mu^{m} \sigma - \mu^{m} \sigma \phi D m^{\phi - 1} \right)
\]

\[
\dot{m} + \dot{b} = \dot{G} + m \left( \rho + \mu^{m} \sigma - \mu^{m} \sigma \phi D m^{\phi - 1} \right) + (1 + \rho + \mu^{g} \sigma - (1 + 2n) \eta_{1} - \mu^{g} \sigma (m + b)^{\phi - 1}) b - (1 + 2n) \eta_{0} \]

\[
\dot{\theta} = \frac{\theta}{\alpha} \left[ (\rho + \delta) - (\Phi - w - (\eta_{0} + \eta_{1} b)) \frac{\theta^{-\alpha}}{A_{\gamma}} \right]
\]

\[
\dot{n} = \theta^{1-\alpha} (1 - n) - \delta n
\]

As in the previous equilibrium, the evolution of new jobs and labor market tightness depend on the evolution of public liabilities and their corresponding real values. However, given that there exist an interest rate spread, government policies will have another channel, the substitution between private and public assets, to affect equilibrium outcomes. As a result, macroprudential, monetary and fiscal policies are going to be even more intertwined.

**Steady States**

After imposing the steady state conditions, the monetary steady state solves the following fixed point equation for real bonds

\[
b \left[ \Sigma_{2} - \mu^{g} \sigma D \phi (m + b)^{\phi - 1} \right] = \eta_{0} + \eta_{1} b + \pi m - \dot{G} + \frac{2(\eta_{0} + \eta_{1} b)(\varepsilon_{1} - \eta_{1} b)^{1-\alpha}}{(\varepsilon_{1} - \eta_{1} b)^{\alpha} + \Sigma_{1}}
\]

where \( \varepsilon_{1} = \Phi - w - \eta_{0}, \Sigma_{1} = \delta ((\rho + \delta) A_{\gamma})^{1-\alpha}, \Sigma_{2} = 1 + \rho + \mu^{g} \sigma, \) and \( m = \left( \frac{D \phi m^{\phi} \sigma}{\rho + \mu^{g} \sigma} \right)^{1-\phi} \).

Since there is no close form solution for real bonds and we have already calibrated the model in Section 4.2, we do not provide conditions that deliver existence of a unique monetary equilibria. In Section 5.1

\(^{27}\)Recall that the private provision of liquidity is given by \( L^{P} = \pi \gamma \theta^{\alpha} \).
we provide some quantitative examples. It is easy to check that the monetary steady state reported in subsequent tables is unique. Next, we establish the properties of the interest rate spreads in terms of labor market conditions.

**Proposition 5** An increase in the rate at which jobs are destroyed, the vacancy costs and the labor matching efficiency always increases the interest rate spread between private assets and government bonds.

These results simply highlight that when the rate at which jobs are destroyed, the vacancy costs and the labor matching efficiency increase, firms become more valuable as their assets become more scarce. As we can see, not only government policies are key in affecting the degree of substitution between private and public assets.

**Local Dynamics**

As in the previous section, the dynamic equilibrium describing this economy is such that the evolution of labor market outcomes are not independent of the real value of government debt and nominal bonds. Relative to the equilibrium described in the previous section, the evolution of real bonds is now changed as there is now a spread between the return on nominal bonds and private liabilities. This substitution channel will be key in delivering different equilibrium properties. The associated Jacobian evaluated at the steady state for this new equilibrium is given then by

\[
J_{ss} = \begin{bmatrix}
\psi_1 & 0 & 0 & 0 \\
-\psi_2 & \psi_3 & 0 & -\psi_4 \\
0 & \psi_5 & \psi_6 & 0 \\
0 & 0 & \psi_7 & -\psi_8
\end{bmatrix}.
\]

The corresponding characteristic equation of this Jacobian is given by

\[
p(\lambda) = (\psi_1 - \lambda)[(\psi_3 - \lambda)(\psi_6 - \lambda)(-\psi_8 - \lambda) - \psi_4 \psi_5 \psi_7];
\]

where the different elements of the Jacobian are

\[
\psi_1 = (1 - \phi)(\rho + \pi + \mu^m \sigma); \quad \psi_4 = 2(\eta_0 + \eta_1 b); \quad \psi_5 = \frac{\eta_1 \theta^{1-\alpha}}{\alpha A \gamma}; \quad \psi_6 = \frac{\theta^{-\alpha} (\Phi - \omega)}{A \gamma};
\]

\[
\psi_3 = 1 + \rho + \mu^b \sigma - \mu^\theta \sigma \phi D(m + b)^{\phi - 1} - (1 + 2n)\eta_1 + \mu^\theta \sigma \phi (1 - \phi) D(m + b)^{\phi - 2};
\]

\[
\psi_7 = (1 - \alpha)(1 - n)\theta^{-\alpha}; \quad \psi_8 = (\theta^{1-\alpha} + \delta);
\]

where \( b \) is the solution to equation (22), \( m \) are steady state real balances, \( \theta \) is the market tightness and \( n \) represents the steady state equilibrium employment.\(^{28}\)

### 6.1 Taxing Just OTC Traders

**CHECK!!!**

In order to isolate the effect of distortionary taxation from that of provision of private liquidity, we now consider the case where only OTC-traders are taxed. As in the case where fiat money does not provide

\(^{28}\)The values \( \Omega_6 \) and \( \Omega_8 \) can not be computed as \( \nu_b \) is not pinned down due to the nominal indeterminacy. Nevertheless, we can easily determine the corresponding dynamic equilibrium properties even if the equilibrium exhibits nominal indeterminacy as \( a_1, a_2 \) and \( a_3 \) are independent of \( \nu_b \).
enough liquidity, when the fiscal authority just taxes OTC-traders, the economy displays a dichotomy between the labor and asset markets. It is easy to show that in this new environment the monetary steady state that is implicitly given by the following equations

\[ b(1 + \rho + \mu^g\sigma - \eta_1 - \sigma\mu^gD\phi(m + b)^{\rho-1}) = \pi m - \mathcal{G} + \eta_0; \]  

where \( m = \left(\frac{D\phi\mu^m\sigma}{\rho + \pi + \mu^m\sigma}\right)^{\frac{1}{\rho-2}} \) and the rest of equilibrium observables for the labor market are

\[ \theta = \left(\frac{\Phi - w}{A\gamma(\rho + \delta)}\right)^{\frac{1}{\alpha}}; \quad n = \frac{\theta^{1-\alpha}}{\theta^{1-\alpha} + \delta}. \]

Note that multiple steady states can not be ruled out.

The corresponding characteristic equation of this Jacobian is given by

\[ p(\lambda) = (\psi_1 - \lambda)(\psi_3 - \lambda)(\psi_6 - \lambda)(-\psi_8 - \lambda); \]

where the different elements of the Jacobian are

\[ \psi_1 = (1 - \phi)(\rho + \pi + \mu^m\sigma); \quad \psi_6 = \frac{\theta^{-\alpha}(\Phi - w)}{A}\gamma; \quad \psi_8 = (\theta^{1-\alpha} + \delta); \]

\[ \psi_3 = 1 + \rho + \mu^g\sigma - \mu^g\sigma\phi (m + b)^{\rho-1} - \eta_1 + \mu^g\sigma\phi(1 - \phi)D(m + b)^{\rho-2}; \]

where \( b \) is the solution to equation (23), \( m \) are steady state real balances, \( \theta \) is the market tightness and \( n \) represents the steady state equilibrium employment.

The asset market eigenvalues are given by

\[ \lambda_1 = \psi_1; \quad \lambda_2 = \psi_3. \]

Finally, the labor market eigenvalues are

\[ \lambda_3 = -\left(\delta + \left(\frac{\Phi - w}{(\rho + \delta)A\gamma}\right)^{\frac{1}{\alpha}}\right), \quad \lambda_4 = \rho + \delta. \]

It is important to highlight that having different equilibrium notion of liquidity delivers an interest rate spread between nominal bonds and private assets. This liquidity property drastically changes the dynamic properties. This is the case as the underlying environment has frictions that alter the price of fiat currency relative to public and private securities. This mechanism can not be observed in environments where financial markets are complete or private and public liabilities are perfect substitutes.

### 6.2 Quantitative Exercise

In order to evaluate the impact of macroprudential, monetary and fiscal policies in this new equilibrium, we borrow the same calibration as in Section 4.2. However, in order for all government liabilities to not be able to provide the liquidity needs of OTC-traders, liquidity services have to be different. In particular, in order for this equilibrium to exist, while keeping the labor market characteristics the same across calibrations, we need to introduce a liquidity shock so that the level of utility per unit per liquidity service, \( D \), goes from 18 to 3.22. This captures disruptions in the financial market relative to normal times.

Under this new calibration, it is easy to check that the different steady state equilibria reported in
this section are unique. When computing equilibria we consider monetary, fiscal and macroprudential parameters \((\pi, \eta_0, \eta_1, \mu^m, \mu^g, \rho, \theta, \pi, n, m, b, \rho - r^g, \theta, \lambda_1, \lambda_2, \lambda_3, \lambda_4)\) such that: the different fiscal policy parameters yield steady state equilibria with positive real government liabilities; labor market outcomes that are positive; profits are positive and that all assets are enough, but not just government liabilities alone, to meet the liquidity needs of OTC-traders. Table 3 reports some monetary equilibria with the corresponding fiscal and macroprudential parameters values, money growth rate, steady state asset and labor market outcomes and the corresponding eigenvalues.

| \(\eta_0\)   | 0.18 | 0.18 | -0.1 | -0.01 | -0.01 |
| \(\eta_1\)   | 0.16 | 0.16 | 1.012 | 1.012 | 0.8  |
| \(\mu^m\)    | 0.0001 | 0.0001 | 0.001 | 0.01  | 0.01 |
| \(\mu^g\)    | 0.005 | 0.005 | 0.005 | 0.3   | 0.3  |
| \(\pi\)      | 0.01  | -0.001 | -0.001 | -0.001 | -0.001 |
| \(\theta\)   | 0.8878 | 0.8878 | 186.8 | 261.9 | 252.9 |
| \(n\)        | 0.9063 | 0.9063 | 0.9774 | 0.9794 | 0.9792 |
| \(m\)        | 0.00056 | 0.00141 | 0.02728 | 0.2786 | 0.2786 |
| \(b\)        | 0.7236 | 0.7236 | 0.1992 | 0.05829 | 0.0825 |
| \(\rho - r^g\) | 0.00013 | 0.00012 | 0.0073 | 0.2460 | 0.2184 |
| \(\lambda_1\) | 0.01658 | 0.0083 | 0.009 | 0.01575 | 0.01575 |
| \(\lambda_2\) | -1.111 | -1.111 | -4.425 | -4.854 | -4.808 |
| \(\lambda_3\) | 0.3612 - i 0.10812 | 0.3612 - i 0.10812 | -1.977 | -2.158 | -1.483 |
| \(\lambda_4\) | 0.3612 + i 0.10812 | 0.3612 + i 0.10812 | 0.1129 | 0.1124 | 0.1119 |

Table 2: Equilibrium outcomes when all agents are taxed.

In contrast to the case where all government liabilities are able to provide all required liquidity, the equilibrium is determinate no matter the type of fiscal policy provided the central bank deflates. Moreover, endogenous volatility is typically observed under a passive fiscal policy, yielding also indeterminate equilibria. The particulars, of the fiscal and macroprudential policy parameters \((\eta_0, \eta_1, \mu^m, \mu^g)\) are critically important in determining the degree of substitution between private and public (interest rate spreads) assets as well as the rate of convergence to the steady state. Finally, we note that even when money is not quantitatively significant in financial markets, \(\mu^m\) is very low, the equilibrium notion of moneyness or liquidity is extremely important in yielding determinate equilibrium.

To have a better understanding of the role of private provision of liquidity, we consider the non-distortionary fiscal environment where only OTC-traders are taxed so that taxes are non-distortionary. The resulting monetary equilibria are reported in Table 3.

| \(\eta_0\)   | 0.18 | 0.18 | 0.1001 | 0.1001 |
| \(\eta_1\)   | 0.16 | 0.16 | 1.012  | 1.012  |
| \(\mu^m\)    | 0.0001 | 0.0001 | 0.1  | 0.1   |
| \(\mu^g\)    | 0.054 | 0.054 | 0.3   | 0.3   |
| \(\pi\)      | 0.001 | -0.001 | -0.001 | -0.001 |
| \(\theta\)   | 337.7 | 337.7 | 337.7  | 337.7  |
| \(n\)        | 0.9808 | 0.9808 | 0.9808 | 0.9808 |
| \(m\)        | 0.001128 | 0.001406 | 0.6516 | 0.6516 |
| \(b\)        | 0.1161 | 0.1161 | 0.02326 | 0.07273 |
| \(\rho - r^g\) | 0.163 | 0.1625 | 0.0246 | 0.0078 |
| \(\lambda_1\) | 0.8501 | 0.8498 | -0.01652 | 0.01517 |
| \(\lambda_2\) | 0.009825 | 0.08325 | 0.08325 | 0.08325 |
| \(\lambda_3\) | -5.0205 | -5.205 | -5.205 | -5.205 |
| \(\lambda_4\) | 0.112 | 0.112 | 0.112 | 0.112 |

Table 3: Equilibrium outcomes when only OTC traders are taxed.

As we can see, the equilibrium notion of liquidity drastically changes the dynamic properties. In contrast
to the case where all government liabilities were able to meet the liquidity needs of OTC-traders, there exist multiple steady states when the government follows an aggressive fiscal policy and there is deflation. The steady state is associated with a larger interest rate spread is determinate while the steady state with the lower spread is indeterminate. Moreover, the specifics of the macroprudential policy directly affects the dynamic properties of equilibrium. These monetary equilibria clearly emphasize the importance of modelling frictional decentralized financial markets as the implied equilibrium liquidity notion resulting from these models drastically change the kind of stabilization policies even when there is no distortionary taxation.

7 Conclusions

Since the onset of the global financial crises there has been renewed interest in the study of financial frictions, provision of private liquidity and trading in OTC markets. Policies have been enacted to reduce unemployment while trying to stabilize financial markets. These policy actions taken by government around the world, clearly highlight the need to better understand the potential channels through which governments, by managing their liabilities, affect the price, debt and unemployment dynamics.

This paper investigates the interactions of macroprudential, monetary and fiscal policies in economies with frictional over the counter financial and labor markets. In this environment, firms intimately link labor and asset markets by hiring workers and issuing equity. Thus policies designed to affect tax revenues will have consequences for the provision of liquidity in the asset market. In particular, the ability of firms to issue their own equity, which facilitates trading in OTC markets, is directly affected by all government policies. This is the case as they directly impact their ability to hire workers and make profits. Thus, the value of assets and their liquidity properties are shaped by fiscal, monetary and macroprudential policies. Moreover, there is an expectational channel through which government policies affect the equilibrium price level, as they change expected returns to both nominal and real assets. Thus the evolution of nominal prices and unemployment critically depend on the interactions between current and expected future government policies.

We show that traditional policy prescriptions to stabilize the economy in frictionless financial and labor markets are not robust. Once decentralized labor and financial markets are taken into account the nature of the stabilization policies critically depend on the equilibrium notion of liquidity that is shaped by all government policies. By explicitly modelling exchange and explicitly considering macroprudential, monetary and fiscal policies, we can have a holistic understanding of how policy design affects the liquidity and unemployment, the two basic pillars of the central bank’s dual mandate.

References


**Appendix**

**Proof Proposition 2** The left hand side of equation (17) is always increasing in $\theta$ while the right hand side is monotonically decreasing in $\theta$ whenever $\eta_0(1 + \rho) + \eta_1 \varepsilon_0 > \eta_1 \eta_0$. The steady state is unique whenever the left hand side evaluated at $\theta = 0$ is smaller than the right hand side, which is the second condition stated in the proposition.

**Proof Proposition 3** Note that the value of the firm is an increasing function of $\theta$. It is easy to show that the left hand side of equation (17) does not depend on $\mu^m$, $\eta_0$ nor $\pi$. In contrast the right hand side of equation depends on $\mu^m$, $\eta_0$ and $\pi$. It is easy to show that when $\eta_1 > 1 + \rho$ the right hand side of equation (17) is always increasing with $\mu^m$ and $\eta_0$. In contrast, the right hand side of equation (17) is always decreasing in $\pi$. 

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Proof Proposition 4  The demand for real bonds increases with employment which is reduced with increases in the job destruction rate, vacancy costs and matching efficiency.

Proof Proposition 5  

The interest rate spread between the return to private assets and public liabilities is given by

\[ r - r^g = \rho - r^g = \mu^g \sigma[D_\phi(m + b)^{\phi-1} - 1] \]

where \( m = \left( \frac{D_\phi \mu^m \sigma}{\rho + \pi + \mu \sigma} \right)^{1/\phi}. \) The properties of this spread depend on how real government liabilities are affected by labor market conditions and monetary policy.

It is easy to show that the left hand side of (22) is independent of labor market conditions while the right hand side is always increasing in the rate at which jobs are destroyed and an increase in the vacancy costs and efficiency in the matching in the labor market. These properties imply the labor market results of the proposition.