Non-standard monetary policy measures, monetary financing and the price level

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Abstract

In the face of the financial crisis, central banks have introduced a variety of non-standard measures to support the functioning of financial markets and the transmission of monetary policy. These measures underpin the conduct of monetary policy aimed at the maintenance of price stability. Yet such non-standard measures may entail risks. They have profound implications for the structure of central bank balance sheets and for the interaction of monetary and fiscal policies. Using the literature on the fiscal theory of the price level.as a starting point, this paper explores some of the potential risks to stability-oriented monetary policy posed by such non-standard measures and discusses how the design and conduct of the measures can address or mitigate these risks. In particular, the paper shows that non-standard measures must be limited in scope and/or duration. Failure to ensure such limitation .for example, by permitting a de facto dependence of the fiscal authorities and/or financial sector on the quasi-fiscal by-products of non-standard measures .may lead to a drift in long-term price developments away from price stability. Such risks should be recognised at the time non-standard measures are designed and implemented, being weighed against the often pressing needs of the immediate financial crisis.

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1 Introduction

In the face of the financial crisis and its aftermath, monetary policy faces considerable challenges. Standard models of monetary policy – not least the canonical new Keynesian model (Woodford (2003)) – have been found wanting.

A typical response to these failings has been to augment standard models with financial frictions, so as to allow a greater role for the monetary, credit and financial variables that have clearly played a prominent part in recent macroeconomic developments. Important examples of this agenda include: Christiano, Motto and Rostagno (2003), Gertler and Karadi (2009) and Curdia and Woodford (2010). Significant progress has been made in this direction: but it is at least open to question whether the rather limited augmentation of standard models is sufficient to address current, vastly changed circumstances.

An alternative, parallel approach takes the fundamental origins of inflation more seriously, exploring the interactions among the balance sheets of the central bank, government and private sector. In recent years, a new environment for monetary policy making has materialised: non-standard monetary policy measures with direct implications for central bank balance sheets have been introduced; very large fiscal deficits and mounting public debt have emerged; and significant (explicit and implicit) public liabilities have accumulated, largely owing to the distressed state of the global financial system. In this context, the nexus among money creation, fiscal sustainability and private expectations may become more central to monetary policy making, as the potential for the emergence of more fundamental risks to price stability – beyond those associated with the business cycle dynamics captured in standard analysis – becomes apparent.

This paper offers a starting point for addressing such issues. In the context of a simple macroeconomic model, we explore the benefits of and limits to non-standard monetary policy measures. Given the rapid pace of events during a financial crisis, central banks have to act promptly and decisively to support market functioning, avoid contagion and underpin the transmission of monetary policy. But the longer-term consequences of such actions also need to be taken into account. In this context, it is crucial to distinguish the underlying shocks along various dimensions: are they temporary or permanent? do they affect the liquidity or solvency of the financial sector (or both)?

Unsurprisingly, we find that the appropriate central bank policy response to the emergence of financial tensions depends on the nature of the underlying shock. While the response to liquidity shocks can – and should – be aggressive, greater caution is required when addressing solvency issues and / or undertaking other actions of a quasi-fiscal nature, such as subsidising certain financial institutions or activities. Over

some range, the latter actions – labelled "credit policy", following Goodfriend (2011)) – may help to stabilise the financial sector and economic activity in the face of financial crisis, while remaining consistent with (indeed, supportive of) the pursuit of price stability. Yet the scope for pursuing such actions is not without limit. In particular, the capacity of the central bank to engage independently in credit policy without endangering the maintenance of price stability is circumscribed by general equilibrium considerations deriving from the so-called fiscal theory of the price level. And, even if the implementation of non-standard measures leaves the steady-state rate of inflation unchanged at the target level, risks to the outlook for price stability may nonetheless increase, as the threshold at which such fiscal considerations become relevant is approached.

More specifically, we develop a simple model to explore interactions between the central bank's balance sheet and that of the government. We demonstrate that separating the two – say by a legal prohibition of central bank financing of government obligations (along the lines of the role played in the euro area by Article 123 of the Lisbon Treaty) – provides an important bulwark to price stability. Before the crisis, such considerations were treated as second order: now, they take centre stage. In current circumstances, we argue for vigilance: the danger exists that an incautious use of non-standard measures to address downside risks to price stability stemming from the business cycle developments associated with financial tensions may unleash deeper monetary forces that create upside risks to price stability over the longer term. Containing such risks – and thereby freeing monetary policy to address the conjunctural challenges – relies on the institutional foundations of the monetary policy, of which the prohibition of monetary financing is a cornerstone.

The remainder of the paper is organised as follows. Section 2 reviews briefly the academic literature on the interaction between monetary and fiscal policies and their potential implication for price developments. Section 3 describes relevant recent developments, focusing on the nature of nature of non-standard monetary policy measures introduced to address the challenges posed by the 2007-2010 financial crises. Section 4 outlines the simple theoretical model, and Section 5 describes various steady-state solutions to this model. The implications of the model are discussed in Section 6. Section 7 concludes.

2 Existing literature

The starting point of this paper is an investigation of the interactions between monetary and fiscal policy at times of financial crisis (and associated fiscal stress). It has been well-documented that the fiscal costs of financial crisis can be large (e.g. Reinhart and Rogoff (2009); Laeven and Valencia (2010)). Dramatic

developments in public deficits and debt may have implications for the conduct and efficiency of monetary policy, as well as creating risks to price stability – on both the up and downside – to which central banks with price stability mandates will have to respond.

Such an investigation appears timely: for example, in assessing the current configuration of macroeconomic policies in the United States, Hamilton (2009) remarks that *"every hyperinflation in history has two ingredients: ... a fiscal debt for which there was no politically feasible ability to pay with tax increases or spending cuts* [and] *a central bank that was drawn into the task of creating money as the only way to meet the obligations that the fiscal authority could not."* Similar concerns have been expressed in other jurisdictions. For a central bank with the mandate to maintain price stability – or given any broader objective of macroeconomic stabilisation – the stakes are therefore high.

The concerns expressed by Hamilton and others are intimately connected with the recent implementation of so-called non-standard monetary policy measures by central banks, aimed at containing the financial crisis (Chailloux, Gray, Klüh, Shimizu and Stella (2008), Borio and Disyata (2009) and Aït-Sahalia, Andritzky, Jobst, Nowak and Tamirisa (2010)). Such measures have led to a substantial expansion of central bank balance sheets, which some observers associate with a 'loss of control over the money supply' that portends higher inflation in the future (Meltzer (2009)).

As discussed in detail in Section 3, non-standard measures were introduced in the face of the challenges posed by the emergence of financial turmoil in August 2007. They were subsequently extended: first, after the escalation into financial crisis with the failure of Lehman Bros. in September 2008; and subsequently, with the intensification of the European sovereign debt crisis in April/May 2010. While the connection between monetary and fiscal policy is immediate in the lattermost case, other central bank actions to support market functioning and/or specific financial institutions in the face of a financial panic may also embody elements of subsidisation and credit direction – issues that traditionally fall in the domain of fiscal policy. The potential 'quasi-fiscal' implications of non-standard monetary policy measures therefore need to be treated seriously.

More generally, in his taxonomy of central bank policies, Goodfriend (2011) distinguishes among monetary policy, interest-on-reserves policy and credit policy. Monetary policy centres on controlling the stock of 'high-powered money', i.e. reserves held by banks at the central bank. Interest-on-reserves policy naturally concerns how such reserves are remunerated (a novel policy in the United States, but with a long pedigree in other countries, including in the euro area). And credit policy concerns portfolio choices on the central bank balance sheet that do not influence the stock of reserves, e.g. regarding the

composition of the assets held by the central bank.

Central bank credit policy works through the central bank acting as an intermediary between private borrowers and lenders. It exploits its own creditworthiness – an exceptional feature of the central bank at times of generalised financial distress – to ensure the flow of financing from private savers to private borrowers of its choice (Giannone, Lenza, Pill and Reichlin (2011)). It is thus engaged in a distributional activity and exposes itself (and ultimately tax payers and/or money holders) to financial loss. The quasi-fiscal nature of such activities is immediately apparent. Indeed, Goodfriend (2011) goes as far as to say: *"the correct way to think of central bank credit policy is as debt-financed fiscal policy."*

Within this framework, the source of the central bank's 'exceptional creditworthiness' becomes key. Two views can be distinguished in the literature. First, the central bank's creditworthiness can derive from its ability to issue monetary liabilities that are legal tender. By law, such liabilities can be used to satisfy any outstanding financial obligation. As a result, any loss incurred by the central bank in the course of implementing its credit policy can be covered by forcing the private sector to accept the paper monetary liabilities of the central bank – in potentially unlimited amounts – to meet that loss. In such circumstances, central bank losses are covered by diluting the real value of money, at the expense of existing money holders. A second, alternative view sees the creditworthiness of the central bank relying on the tax-raising powers of its owner, the government. This assumes that, in the event of losses stemming from credit policy, the central bank would ultimately be re-capitalised by the fiscal authorities. In this context, central bank losses would be the responsibility of current and future tax payers.

However, both these sources of 'fiscal backing' for the central bank are limited (Buiter (2008)). And it is when these limits are reached that monetary/fiscal interactions can influence the outlook for price stability, and disrupt or constrain central banks' pursuit of their price stability mandate (Buiter (2006)).

As regards the former perspective, the creditworthiness of the central bank is underpinned by its ability to extract resources from money-holders via an "inflation tax" (Buiter (2007)). When the fiscally-driven supply of monetary liabilities exceeds the private sector's demand for those liabilities, the price of money will fall and thus the general price level (which, in this 'monetarist' characterisation, is the inverse of the price of money) will rise. The implications for inflation are therefore immediate. But, as emphasised by Cagan (1956) and subsequently explored empirically by Sargent (1982), if money demand is sensitive to the rate of inflation – as is likely for non-interest bearing banknotes – then expectations of higher inflation will further diminish the demand for money. A Laffer curve for the inflation tax will emerge: higher inflation rates will shrink the stock of money holdings, such that the overall tax revenue

falls. Such dynamics may place the price level on an explosive, hyperinflationary path. Considerations of this type appear to underlie the concerns expressed by Hamilton (2009) recounted above.

Turning to the latter perspective, Davig, Leeper and Walker (2010) argue that the tax-raising power of the government is itself limited by both political and practical constraints. In short, a Laffer curve for conventional taxation will also constrain the fiscal backing of the central bank. More generally, on the basis of existing legislative commitments, governments face large unfunded liabilities (stemming from both longer-term structural demographic issues and more immediate responsibilities assumed during the financial crisis), which cannot easily be abrogated. Such 'fiscal limits' can be embedded in a macroeconomic model embodying the so-called fiscal theory of the price level (Leeper (1991); Sims (1994); Woodford (1995)). These models exhibit three crucial features: they have a general equilibrium character; they assume that governments can behave in a so-called 'non-Ricardian' manner (i.e. that they do not obey their intertemporal budget constraints), in part because of the fiscal constraints described above; and they assume that governments do not default. In such a setting, equilibrium can only be achieved if the price level evolves in a manner that erodes the outstanding stock of public debt (and other government liabilities) such that the economy's overall resource constraints are respected.[1] As described by Leeper (2010), this environment can result in deviations from price stability. Rather than explode into hyperinflation as in Cagan (1956), a chronic, undesirably high rate of inflation may emerge.

Even these simplistic accounts of the large existing literature demonstrate that the institutional arrangements governing interactions between the government and central bank, as well as the obligations they assume vis-à-vis the private sector, play a crucial role in determining macroeconomic outcomes. And it is along this dimension – notably with regard to the potential erosion of the institutional (but also operational) independence of the central bank – that many of the concerns surrounding the introduction of non-standard monetary policy measures have been expressed (see Poole (2007), Stella (2009) and Bordo (2010), among others).

3 Central bank measures during the financial crisis

Banks have a special place in the financial system and broader economy (Mishkin (2006)). Their intermediation role is essential to the healthy functioning of the economy. Banks provide payment services (that reduce transaction costs), engage in liquidity and maturity transformation (leading to a more efficient

[1] Authors such as McCallum (2001) and Buiter (2002) have expressed criticism about the non-Ricardian specification of the fiscal theory of the price level. Nevertheless, even these authors recognise that, under certain conditions, fiscal policy can influence the price level when the central bank passively accommodates the fiscal demands placed upon it.

use of capital resources) and monitor and filter information (thereby helping to limit moral hazard and adverse selection problems). Given the significant network externalities that emerge in these contexts, bank failures are not only costly for the economic agents immediately exposed: they also have significant wider repercussions. History offers many examples of major (and often persistent) economic downturns following panics and crises in the banking system (e.g., Friedman and Schwartz (1963) and Bordo and Eichengreen (2002)).

As described by Brunnermeier (2009) and Brousseau, Chailloux and Durré (2009), the recent financial crisis offers another example of this phenomenon. The origins of the crisis are found in the transformation of the banking system over the past two decades, from a "bank-centric" to a "bank-peripheral" structure. Key (and inter-related) elements of this evolution include: the growth of the so-called shadow banking system and other off-balance sheet activities; the rise of the 'originate-to-distribute' business model; and the exponential growth of securitisation and credit risk transfer markets. Over time, these developments have made banks more reliant on market sources of funding, which have progressively replaced traditional sources, such as retail or interbank deposits. This in turn has increased banks' exposure to market liquidity risk and complicated the inter-relationship between liquidity and solvency concerns.

Relative to the post-WW2 experience in advanced economies, the recent financial crisis has proved exceptional in magnitude, duration and scope. Each phase has been associated with the emergence of threats to the banking system, and thus posed substantial systemic risks to the wider economy. First, rising delinquency in US subprime RMBS disrupted interbank money markets (in particular, from August 2007), as questions emerged about the quality of banks' balance sheets exposed to such instruments and perceived counterparty risk rose. Second, the failure of Lehman Bros. in September 2008 significantly intensified such money market tensions: if such a large and prominent institution could (and would be allowed to) fail, who was safe? Third, even as the functioning of money markets improved, tensions remained or grew in other market segments (e.g., ABS and commercial paper markets in the United States; covered bank bond and sovereign debt markets in Europe).

Each phase of the crisis has been associated with the same underlying concerns: liquidity problems have emerged for *all* banks (and other market participants) as markets seize up, owing to concerns about the solvency of *some* banks, the identity of which was uncertain to the market as a whole (see Freixas and Rochet (2000), Diamond and Rajan (2005) and Heider, Hoerova and Holthausen (2009)). In this context, separating sound banks with liquidity problems from unsound banks with solvency problems becomes next to impossible, especially as the dynamic interaction between liquidity and solvency risk

is both complex and potentially rapidly evolving. Yet adopting a policy of benign neglect towards the financial sector in the expectation that the market will uncover the necessary information is also nigh on impossible. Given the importance of the banking system to the economy in general and, in particular, its crucial role in the transmission of monetary policy, central banks have found it necessary to intervene (especially in the form of non-standard policy measures) to support market functioning and thereby financial, macroeconomic and, ultimately, price stability.

The measures introduced in this context have been described in detail elsewhere. We do not repeat these accounts here. They have had profound implications for central bank balance sheets (see Figure 1 in the Annex). The available evidence suggests that such measures have helped to stabilise the financial system, maintain monetary policy transmission and support economic activity (see Aït-Sahalia et al. (2010) for the United States; and Lenza, Pill and Reichlin (2010) or Baumeister and Benati (2010) for the euro area), even if the macroeconomic impact of the crisis remains significant. But since their introduction remains relatively recent, empirical assessment of the longer-run implications of such measures – especially with regard to their impact on price stability, the primary objective of monetary policy – is, as yet, impossible. Of particular relevance in this context is the potential for non-standard measures to have a (possibly inadvertent) quasi-fiscal element that, if not appropriately limited in scope and/or duration, may threaten price stability over longer horizons (Schwartz (1992)). To illustrate such concerns against the background of the preceding discussion, it may be that actions intended to provide liquidity support to a financial institution viewed as solvent – a legitimate central bank activity – could, in certain circumstances, morph into the prolonged provision of solvency support to that institution, which is a fiscal responsibility that would naturally fall to the government. Mechanisms through which such a transformation might occur include: offering central bank refinancing operations to financial institutions at a subsidised interest rate (Buiter (2010)); mispricing of the collateral accepted by central banks in their refinancing operations; and decisions regarding the pricing and/or composition of central bank's asset purchases (Goodfriend (2011)). Against this background, institutional safeguards may be required to support the necessary separation of the central bank and government balance sheets, which is at particular risk as times of financial stress.

This issue is at the heart of the current debate in the United States about the need for a renewed Treasury-Fed Accord.[2] In Europe, such considerations underpin the institutional framework defining

[2] To some extent, the joint statement by the US Treasury and the Federal Reserve on 23 March 2009 could be seen a step towards clearer separation of responsibilities between the monetary and fiscal authorities. See also Hetzel and Leach (2001) for a recollection of events that eventually led to the 1951 Fed-Treasury Accord and Goodfriend (2011) for an assessment of its relevance in pre-crisis times.

Economic and Monetary Union, notably the prohibition of monetary financing established by Article 123 of the Lisbon Treaty.[3] From the outset, the architects of the European single currency took the view that the financing of public sector deficits by central banks should be avoided. Three broad and inter-related economic rationales supported this position. First, it was obviously crucial to ensure "monetary dominance" over the price level, ensuring that fiscal indiscipline did not undermine the maintenance of price stability. Second, the prohibition of monetary financing was seen as a cornerstone of the central bank's credibility and stability-orientation; it was required to underpin the institutional and financial independence of the central bank.[4] Third, the prohibition of monetary financing was intended to maintain financial discipline on the public sector (avoiding 'soft balance sheet constraints') and thus serve fiscal responsibility.

4 A simple model

In this section, we develop a simple model to explore potential rationales for non-standard monetary policy measures and the risks that may be associated with them. The starting point for this exercise is the standard New Keynesian DSGE model (in the spirit of Woodford (2003)). The model consists of three sectors: a private sector (comprising households and productive firms); a government; and a central bank.

Assigning these labels simplifies the presentation that follows. Nonetheless, it should be recognised from the outset that the distinctions relevant for our model are not defined on an institutional basis. Rather, they concern economic behaviour. The private sector consists of agents that always respect their intertemporal balance sheets constraints: they are Ricardian. By contrast, the government sector

[3] The details of the prohibition are defined in the associated Council (EC) Regulation No. 3603/93. Under Article 123(1) of the Treaty (which prohibits monetary financing), the European Central Bank (ECB) and the 27 national central banks (NCBs) of the European Union are prohibited from providing any type of credit facility (including overdraft facilities) to and from purchasing debt instruments directly (i.e. in the primary market) from governments or any EU public body (i.e. including Community institutions or bodies, central/regional/local public authorities or any body governed by public law). An exemption is made for publicly-owned credit institutions in the context of monetary policy operations. By contrast, the acquisition by NCBs or the ECB of such public debt instruments in the secondary market is, in principle, allowed as long as they are not used to circumvent the objective of Article 123 of the Treaty (in accordance with the above-mentioned regulation). Over time, the Governing Council of the ECB has also taken various decisions towards a strict interpretation of this regulation in order to avoid indirect ways to circumvent the prohibition. See Drevina, Durré, Lenihan, Pill and Valla (2010) for further details.

[4] It is worth recalling that financial independence and the prohibition of monetary financing are connected. For example, extension of central bank tasks at the expense of the core monetary policy function would both erode financial resources over time (creating risks to financial independence) and may entail assumption of quasi-fiscal activities (implying monetary financing). Similarly, funding public sector responsibilities would erode the financial resources needed to conduct monetary policy (and also increase the risk of potential future losses), thereby creating risks to the financial independence of the central bank. In this respect, establishing full institutional independence may not suffice to ensure monetary dominance over the price level. See also the theoretical discussion in Castellani and Debrun (2001).

may, on occasion, depart from Ricardian behaviour, taking spending decisions that are inconsistent with respecting its intertemporal balance sheet.[5] Against the backdrop of recent events, one may imagine that poor governance and adverse incentives in the financial system may have led to the emergence of such non-Ricardian behaviour also in some parts of the private sector. In our analysis, we implicitly consolidate such behaviour with that of the government. The crisis-related nationalisation of many financial institutions reflects the impact of soft-budget constraints on this behaviour, which underpins the non-Ricardian view of the government sector discussed below.

4.1 Private sector

4.1.1 Households

Households are modelled in the form of a representative agent, who maximises utility:

$$\max_{c,\ h,\ m,\ B^p,\ L^{cb}} E_0 \sum_{t\ =\ 0}^{\infty} \beta^t\ U(c_t, h_t, m_t)\ =\ \sum_{t\ =\ 0}^{\infty} \beta^t\ \left[u(c_t) - f(h_t) + \eta\ L\left(\frac{m_t}{\overline{m}}\right)\right]$$

subject to the budget constraint:

$$\left(\frac{W_t}{p_t} - \tau_t\right)\ +\ R_{t-1}\ \frac{B^p_{t-1}}{p_t}\ +\ \frac{L^{cb}_t}{p_t}\ +\ i_{t-1}\ \frac{m_{t-1}\ p_{t-1}}{p_t}\ +\ \frac{D_t}{p_t}\ \geq\ (c_t + m_t)\ +\ \frac{B^p_t}{p_t}\ +\ R_{t-1}\ \frac{L^{cb}_{t-1}}{p_t}$$

where the notation is standard: c_t is consumption at time t; h_t is labour supplied by the household; m_t is holdings of central bank money (hence for then referred to as 'reserves'); W_t is the nominal wage; p_t is the price level; τ_t is the tax imposed on the private sector; R_t is the (gross) nominal yield on government bonds; B^p_t is the private sector's holdings of government bonds; L^{cb}_t is private sector borrowing from the central bank; i_t is the interest rate paid on reserves; and D_t is the nominal dividend payment the household receives as an owner of the monopolistically competitive intermediate goods producing firms. β is the discount rate; $u(.)$ is the period utility function for consumption; $f(.)$ is the period (dis-)utility function for work; and $L(.)$ is a liquidity function capturing the utility yielded by holding reserves. $u(.)$ is strictly concave ($u_{cc} < 0$) and monotonically strictly increasing in c ($u_c > 0$). $L(.)$ is concave ($L_{mm} \leq 0$), monotonically weakly increasing in m ($L_m \geq 0$) and satiates at the level $\overline{m}$ (such that $L_m = 0,\ \forall m \geq \overline{m}$).

A key feature of this characterisation of the household problem is the separability of consumption and reserve holdings in the household period utility function ($u_{cm} = 0$). As shown by **?**, this assumption implies that the household's demand for reserve balances is determined recursively with respect to consumption decisions. Reserve holdings do not enter the intertemporal IS or Phillips curve equations in this

[5] For example, a "free-rider" attitutde of some states within a monetary union - when individual consequences of fiscal imbalances are lower than for those of the union - may easily lead to non-Ricardian behaviour of governments.

model; rather such holdings are determined in what amounts to a satellite model, taking the chosen level of consumption as given. It is this feature of the set-up that allows central bank decisions to follow the so-called separation principle: liquidity management decisions do not have direct implications for interest rate setting decisions (Manna, Pill and Quirós (2001)).

Solving the representative household's constrained optimisation problem and manipulating the resulting Euler equations gives rise to the following characterisation of household behaviour:

$$u_{c,t+1} \quad = \quad \frac{1}{\beta\ (R_t)}\ \frac{p_{t+1}}{p_t}\ u_{c,t}$$

It is useful to define the spread between the market interest rate (R_t) and the rate paid on reserve holdings by the central bank (i_t) as:

$$\mu_t \quad = \quad \frac{(R_t - i_t)}{R_t} \quad \geq \quad 0$$

which leads to a reserve demand equation of the form:

$$\begin{aligned} m_t \quad &= \quad m\ (c_t,\ \mu_t;\ \overline{m},\ \eta) \\ m_c \quad &> \quad 0, \quad m_\mu \leq 0, \quad m_\eta > 0; \\ \overline{m} \quad &\leq \quad m\ (c_t,\ 0;\ \overline{m},\ \eta) \end{aligned}$$

As shown, an important feature of the household demand for reserves is that it is satiated (i.e. $m \geq \overline{m}$) when $\mu_t = 0$.

Finally, the household's budget constraint is satisfied, noting that from the private sector's perspective government bonds and central bank debt certificates are equivalent (and have the same yield by arbitrage). This gives rise to an expression for holdings of government and central bank debt by the private sector:

$$\frac{(B_t^p - L_t^{cb})}{p_t} \quad = \quad \left(\frac{W_t}{p_t} + \frac{D_t}{p_t} - c_t - m_t - \tau_t\right) \quad + \quad R_{t-1}\ \frac{(B_{t-1}^p - L_{t-1}^{cb})}{p_t} \quad + \quad i_{t-1}\ \frac{m_{t-1}\ p_{t-1}}{p_t}$$

4.1.2 Firms

As we have seen, households own the firms in the economy and receive dividends from them. In line with the standard New Keynesian literature, the final consumption good (y) is produced competitively using intermediate inputs ($y(i)$) according to a Dixit-Stiglitz production function. Intermediate goods are produced in a monopolistically competitive environment using labour input from households (with a linear production function) (see Annex for details).

Following the standard **?** staggered pricing formulation, only a fraction of intermediate goods firms are able to change their prices in any given period. This nominal rigidity introduces rich dynamics into the model. In this paper, we focus on the steady-state behaviour of the economy: in that context, the Calvo pricing assumption serves to produce a negative relationship between steady-state inflation and output, consumption and household welfare. Given staggered pricing, higher steady-state levels of inflation induce greater steady-state dispersion in the price of intermediate goods, thereby exacerbating the real distortion introduced by the monopolistic competition in the model.

4.2 Government

The government inherits an initial stock of outstanding debt (B_0). It raises (lump sum) taxes (τ_t) from households to meet exogenously given liabilities and responsibilities. Characterising the fiscal dynamics in a very stylised manner, one can understand that the private sector "buries" g_t of the each period's production. These buried resources yield no utility to households (i.e. they are not associated with the provision of public goods). The government has to pay for these buried resources. This bill is presented in nominal terms ($G_t = g_t\ p_t$) at the end of the period. Crucially for the functioning of the model, the fiscal authorities meet this bill at the start of the next period: the possibility therefore exists for inflation to erode the real value of these fiscal liabilities in the intervening period.

This gives rise to the following dynamics of the government debt:

$$\frac{B_t}{p_t} \quad = \quad \frac{(R_{t-1})\ B_{t-1}}{p_t} \quad - \quad \left(\tau_t - \frac{g_{t-1}\ p_{t-1}}{p_t}\right) \quad - \quad \psi_t$$

where ψ_t is the seignorage revenue passed to the fiscal authorities by the central bank (to be defined later).

A Ricardian government (i.e. one that respects its intertemporal budget constraint) will vary the tax rate so as to ensure fiscal solvency. This is the classic case of 'passive' fiscal policy. In what follows, we also explore situations where the government's tax raising power is exhausted (e.g. due to political constraints or the existence of a Laffer curve). In other words, we impose an upper bound on the level of lump sum taxation such that:

$$\tau_t \leq \overline{\tau} \qquad \forall t$$

Crucially, the government in this framework does not optimise. Government spending is given exogenously: in the steady-state, the government will raise taxes to cover this spending, as long as it is able to do so. But when the bound on taxation is reached, the government is forced to violate its intertemporal

budget constraint. It is the general equilibrium implications of this non-Ricardian behaviour that lie at the heart of the 'fiscal theory' implications for the price level.

4.3 The central bank

Expressed in nominal terms, the central bank balance sheet has the form:

$$m_t\ p_t \quad = \quad B_t^{cb} \quad + \quad L_t^{cb}$$

where B_t^{cb} are central bank's holdings of government bonds and L_t^{cb} are loans by the central bank to the private sector. The latter allows the central bank to determine the level of the stock of the reserves independently of the stock of government debt.

The seignorage earned by the central bank is given by:

$$\psi_t \quad = \quad \frac{R_{t-1}\ (B_{t-1}^{cb} - L_{t-1}^{cb})}{p_t} \quad - \quad (i_{t-1})\ m_{t-1}\ \frac{p_{t-1}}{p_t}$$

where the timing of coupon and interest payments implicit in the preceding discussion is fully reflected.

The ability of the central bank to raise seignorage revenue is limited by a Laffer curve relationship. When the interest paid by the central bank on reserves (μ_t) is equal to the market rate, the seignorage tax base is large (reserve demand is satiated), but the tax rate (the spread) is zero. And when the spread is large, the tax rate is high but the tax base shrinks as the cost of holding reserve balances increases.

In this context, a maximum steady-state level of seignorage (μ^*) can be calculated, which (as shown in the Annex) depends on the steady-state level of consumption:

$$\psi_t^* = \psi^*(c_{t-1};\ \overline{m},\ \eta)$$

As implicit in the discussion above, once the central bank wishes to raise seignorage revenue, it must introduce a spread between the market interest rate and the rate at which it remunerates reserves. The introduction of such a spread implies that reserve holdings will be below their satiation level ($\overline{m}$). In particular, the seignorage-maximising stock of reserves is bounded between zero and the satiation level:

$$0 \quad < \quad m_{t-1}^* \quad < \quad \overline{m}$$

This illustrates an important point: by contrast with the lump-sum taxation imposed by the government, central bank seignorage is a distortionary tax on reserve holdings.

4.4 Market clearing conditions

Finally, in equilibrium the market for government bonds, money and consumption goods in our model must clear:

$$B_t = B_t^p \; + \; B_t^{cb} \quad \Rightarrow \quad (B_t^p \; - \; L_t^{cb}) \; = \; B_t \; - \; m_t p_t$$

$$y_t \; = \; c_t \; + g_t$$

4.5 Consolidated public sector balance sheet

Combining a number of the relationships above, one can arrive at a consolidated balance sheet for the public sector in this model, which will prove useful in the exposition in the next section:

$$\frac{B_t}{p_t} \; = \; \frac{R_{t-1} \; B_{t-1}}{p_t} \; - \; \left(\tau_t - g_{t-1} \frac{p_{t-1}}{p_t} \right) \; - \; R_{t-1} \frac{p_{t-1}}{p_t} m_{t-1} \; \mu_{t-1}$$

This expression consolidates the balance sheet of the government with that of the central bank. The evolution of public debt over time is driven by three factors: (1) interest payments on the outstanding debt; (2) the primary deficit; and (3) seignorage income generated by the central bank.

5 Steady state solutions to the model

We consider steady state solutions to this model where: (1) consumption is stationary ($c_t = \widetilde{c}$); and (2) the real public debt is stable ($B_t \; / \; p_t = \widetilde{b}$). At this stage, it is also useful to define the (gross) inflation rate as:

$$\pi_t \; = \; \frac{p_t}{p_{t-1}}$$

and thus the steady state rate of inflation as $\widetilde{\pi}$. The real interest rate is then pinned down by the representative household's rate of time preference:

$$\beta \; = \; \frac{\widetilde{\pi}}{\widetilde{R}}$$

Substituting the steady state level of real public debt into the consolidated public sector balance sheet (and assuming stationary steady state values for taxes and public expenditure of $\widetilde{\tau}$ and $\widetilde{g}$ respectively) implies:

$$\frac{(\beta - 1)}{\beta} \; \widetilde{b} \; \; = \; \frac{\widetilde{g}}{\widetilde{\pi}} \; - \; \widetilde{\tau} \; - \; \frac{m_{t-1} \; \mu_{t-1}}{\beta}$$

We can now envisage two steady states in the model, which are usefully discussed in the context of three different "policy regimes".

5.1 Regime 1: Monetary dominance

To commence our analysis, we initially restrict ourselves to a regime where the government is behaving in a Ricardian manner: in other words, when monetary policy is 'active' and fiscal policy is 'passive'. This is sometimes labelled a regime of monetary dominance. To be supported, this regime requires that the government has sufficient 'fiscal space' to meet the steady-state demands placed upon it. This subsection clarifies what such fiscal space means in our framework.

Following Curdia and Woodford (2010), characterising the socially desirable central bank policy (as assessed on the basis of the representative household's welfare) in this regime is surprisingly straightforward.

Given the economic structure facing the central bank, decisions on the level of (market) interest rates (our measure of the 'conventional' monetary policy stance) can be taken independently of decisions regarding the supply of reserves and/or the spread between market rates and the rate at which they are remunerated ('liquidity policy' in this framework).

As regards conventional monetary policy, a vast literature in the spirit of **?** addresses this issue of how to design an interest rate rule that maximises household welfare or stabilises inflation around a given steady state. Given our focus on the steady state in this paper, we do not enter that question here. What we can say, however, is that the optimal steady-state rate of inflation is zero, since this will minimise the real distortion (and thus cost to household welfare) introduced by the staggered pricing assumption. Therefore, in normal circumstances of monetary dominance, it is unambiguous that central banks should pursue price stability. On the basis of this argumentation, in this regime the steady state rate of inflation is at the central bank's target level, $\pi^* = 1$.

Turning to liquidity policy, it is clear that a welfare maximising central bank should satiate the private sector's demand for liquidity. This entails remunerating reserves at the market rate ($\mu_t = 0$), such that $m_t \geq \overline{m}$. The rationale for this approach is straightforward: since reserves are costless to produce and yield utility to households, a welfare-maximising central bank should supply as many reserves as the private sector demands. In other words, demand for reserves should be satiated. This can be seen as a restatement of Friedman's analysis of the optimal rate of inflation, re-cast in a world where central banks can remunerate reserves rather than issuing non-interest bearing cash.

A number of corollaries can be drawn from this prescription for the conduct of liquidity policy in 'normal times'. First, the so-called separation principle between monetary policy and liquidity management holds in this framework: adding more liquidity has no implications for the macroeconomic environment.

Second, in a regime of monetary dominance, a welfare-maximising central bank will never raise seignorage income. This is unsurprising: it is not welfare-improving to resort to a distortionary tax when a non-distortionary (lump sum) alternative is available. Third, because a central bank satiates the demand for reserves, (modest) stationary shocks to the demand for reserves (in the spirit of **?** and captured by η in the model above) should not have an impact on the observed dynamics of the central bank balance sheet. This last point is consistent with the so-called buffering function of the ECB's system of fully-remunerated minimum reserves which was initially introduced at the beginning of the single currency on 1 January 1999. With probably the experience during the 2077-2012 financial crisis a similar arrangement has recently been introduced by the US Federal Reserve. In this regime on welfare grounds, the central bank will always choose to satiate the private sector's demand for liquidity.

The results of this analysis can then be substituted into the consolidated public sector balance sheet, leading to an expression clarifying how the government's tax raising capacity defines the boundary of this first regime:

$$\widetilde{\tau} \quad + \quad \frac{m_{t-1}\ \mu_{t-1}}{\beta} \quad = \frac{\widetilde{g}}{\pi^*} \quad - \quad \frac{(\beta-1)}{\beta}\ \widetilde{b}$$

implying that:

$$\overline{\tau} \quad \geq \quad \frac{\widetilde{g}}{\pi^*} \quad - \quad \frac{(\beta-1)}{\beta}\ \widetilde{b} \quad = \quad \widetilde{g} \quad + \quad \frac{(1-\beta)}{\beta}\ \widetilde{b}$$

The tax raising power of the government must be sufficient to cover current government expenditure and the real servicing cost of the outstanding debt. By implication (and unsurprisingly), a poor fiscal environment – with higher debt and deficit levels – implies the desirable regime of monetary dominance is less likely to emerge.

5.2 Regime 2: Fiscal dominance

Consider an alternative steady state where the bounds on both the government's tax raising capacity and the central bank's seignorage raising capacity are binding. We denote three steady-state values in this regime by hats ($\widehat{x}$) rather than tildas ($\widetilde{x}$). In this case:

$$\begin{aligned} \widehat{\tau} \quad &= \quad \overline{\tau} \\ \widehat{\psi} \quad &= \quad \psi^*(\widetilde{c},\ \overline{m},\ \eta) \end{aligned}$$

where

$$\widehat{c} \quad = \quad \widehat{y} - \widehat{g}$$

Substituting into the consolidated public sector balance sheet:

$$\overline{\tau} \quad + \quad \psi^*(\widetilde{c},\ \overline{m},\ \eta) \quad = \quad \frac{\widehat{g}}{\widetilde{\widehat{\pi}}} \quad - \quad \frac{(\beta-1)}{\beta}\ \widetilde{b}$$

If

$$\widehat{g} \quad \geq \quad \overline{\tau} \quad + \quad \psi^*((\widetilde{y}-\widehat{g}),\ \overline{m},\ \eta) \quad + \quad \frac{(\beta-1)}{\beta}\ \widetilde{b}$$

and the public debt is not to explode, the consolidated public sector balance sheet can only be satisfied by having a steady-state rate of inflation above zero – and thus higher than what a welfare-optimising central bank would pursue:

$$\begin{array}{lll} \widehat{\pi} & = & \dfrac{\widehat{g}}{\left[\overline{\tau} \quad + \quad \psi^*((\widehat{y}-\widehat{g}),\ \overline{m},\ \eta) \quad + \quad \frac{(\beta-1)}{\beta}\ \widetilde{b}\right]} \quad \geq \quad 1 \\ \widehat{\pi} & \geq & \pi^* \quad = \quad 1 \end{array}$$

In this regime, the steady-state value of inflation is $\widehat{\pi} > 1$. A key feature of this steady state is that inflation is away from its target, but does not explode in the manner of the traditional Cagan model. In other words, the economy can evolve into a regime of persistent and chronic inflation, not into an explosive state.

Of course, a stability-oriented central bank will not be happy with this outcome. But the general equilibrium nature of this model renders the pursuit of price stability by monetary policy infeasible. This is the essence of fiscal dominance. In this context, the only mechanism available for the central bank is to promote a more sustainable fiscal cause that re-establishes Ricardian behaviour and thus permits as re-establishment of monetary dominance over the price level.

5.3 Regime 3: 'No man's land'

Finally consider the intermediate case, where conventional tax revenue is insufficient to meet the government's needs, but central bank seignorage is at least potentially sufficient to meet the shortfall:

$$\overline{\tau} \quad \leq \quad \frac{\widetilde{g}}{\pi^*} \quad - \quad \frac{(\beta-1)}{\beta}\ \widetilde{b} \quad \leq \quad \overline{\tau} \quad + \quad \psi^*((\widetilde{y}-\widetilde{g}),\ \overline{m},\ \eta)$$

In this environment, the central bank could refuse to make recourse to the seignorage tax, setting $\mu_t = 0$. This would then imply an outcome equivalent to that in Regime 2 above.

However, an alternative approach would be for the monetary authorities to make recourse to seignorage to cover the shortfall in tax revenue. This will imply that μ will rise in response to any increase in $\widetilde{g}$ to ensure:

$$\frac{\mu\ m\ ((\widetilde{y}-\widetilde{g}),\ \mu;\ \overline{m},\ \eta)}{\beta} \quad = \quad \frac{\widetilde{g}}{\widetilde{\widehat{\pi}}} \quad - \quad \widetilde{\tau} \quad - \quad \frac{(\beta-1)}{\beta}\ \widetilde{b}$$

Strictly speaking, under the regularity condition ensuring the concavity of seignorage income in m there will be two possible values of m (or, equivalently, of μ) that will satisfy this relationship. But a central bank that seeks to maximise private sector welfare in the face of the constraints it faces will always choose the higher value of m (and thus lower value of μ) that is feasible.

In this steady state, inflation is still at the central bank's target $\pi^* = 1$, but the economy suffers from a welfare cost due to the distortionary nature of taxation on reserve holdings.

Note that in this steady state (and in contrast with Regime 1, where the demand for reserves is always satiated and shocks to liquidity preference η play no role), the demand for reserve holdings will be affected by liquidity shocks. In this context, a temporary shock to η combined with a permanent shock to $\widetilde{g}$ can be a toxic combination. The former may encourage the monetary authorities to believe that they can generate sufficient seignorage revenue to perpetuate the low inflation steady state, but as the liquidity shock unwinds, the central bank's inability to do so owing to fiscal theory considerations would become apparent and the economy would shift from Regime 3 to Regime 2 (and thus higher steady state inflation) without any contemporaneous monetary policy mistake. Finally, the importance of the relative size of the public revenues ($\widetilde{\tau}$) and expenses ($\widetilde{g}$) should also not be neglected. As illustrated by Figures in the Annex, once the relative size of public expenses ($\widetilde{g}$) exceeds that of the revenues ($\widetilde{\tau}$) the impact on the inflation rate is immediate in order to maintain the level of real public debt unchanged.[6]

6 Interpretation and discussion

The conclusions of the preceding analysis are summarised in the two panels A and B of Figures 2 in the Annex. Figure 2 (Panel A) illustrates the three regimes identified above. The starting point is the debt-servicing cost faced by the government at the stationary steady state level of government debt ($(1-\beta)\widetilde{b}$ / β). This must be met if the public debt is not to explode. If conventional taxation net of government spending ($\tau - \widetilde{g}$) provides sufficient revenue to service the outstanding debt, no recourse to other sources of funding is required. But should it prove insufficient, recourse must be made to central bank seignorage (ψ_t), which can be collected by reducing the remuneration of reserves to a level below the market rate. Yet this second source of additional revenue is not inexhaustible. Once the seignorage limit (ψ_t^*) is reached, general equilibrium considerations imply that inflation must emerge.

These three regimes imply a mapping from government expenditure to inflation, which is illustrated

[6] The simulation displayed by Figure 3 in the Annex is based on the steady state solution of the model ($\frac{(\beta-1)}{\beta}\widetilde{b} = \frac{\widetilde{g}}{(1+\widetilde{\pi})} - \widetilde{\tau} - \frac{m_{t-1}\,\mu_{t-1}}{\beta}$) with $\widetilde{g}$ arbitrarily fluctuating between [0,3], $\widetilde{\tau}$ between [0,1], $m\mu$ between [0,1] and β set at 0.5.

in Figure 2 (Panel B). In regime 3 ('no man's land'), the central bank is able to maintain price stability. For a central bank with a lexicographic ordering of objectives (with price stability assigned primacy), its mandate provides sufficient guidance for action. However, a welfare-maximising central bank may face a trade-off between, on the one hand, the costly distortions created to reserve holdings by raising seignorage and, on the other hand, the costs in terms of output and consumption of higher steady-state inflation.

What are the practical implications of this analysis? We have moved beyond the proto-monetarist view that inflation is created by a central bank lacking institutional independence being forced to monetize the public debt by a predatory government. In our framework, all actions of the central bank and private sector are voluntary and optimising (subject to the constraints implied by the model). Nonetheless, situations can arise where even an independent central bank fully intending to respect its price stability mandate (or alternatively – but not equivalently – striving to maximise the welfare of the representative household) may be forced to accept rates of inflation greater than those consistent with price stability, even in steady state.

At the root of this uncomfortable outcome is the possibility that, in the midst of financial crisis, central banks are confronted with an irreconcilable dilemma. On the one hand, central banks need well-functioning financial markets and a healthy banking system to ensure the smooth transmission of their monetary policy decisions to the broader economy. Containing the usual cyclical inflationary or deflationary pressures – which may become acute at times of financial crisis – crucially depends on ensuring such transmission is effective. Non-standard central bank policy measures support market functioning and thus serve this requirement. Yet, on the other hand, such non-standard monetary policy measures may embody quasi-fiscal elements, notably through implicit subsidies and/or solvency support to financial institutions as spelled out in Goodfriend (2011). If not limited in scope and/or duration, such measures can erode the central bank's ability to anchor steady-state inflation. This risk is especially severe when the wider fiscal environment is unfavourable. It is intensified when what was initially intended as temporary central bank support evolves into a dependency on the part of either the government or the private sector on that support, as the incentives they face change.

This rather pessimistic observation should not however be overstated. To the extent that liquidity shocks are the fundamental source of the financial tensions, the dilemma disappears. Central banks are the ultimate creator of liquidity: they can produce reserves costlessly in potentially infinite amounts. Supporting market functioning by fully accommodating pure liquidity shocks is thus one element of

optimal central bank behaviour – in normal as well as crisis times. But where the disruptions to the financial system have different sources – rooted in solvency issues or requiring the subsidisation of specific necessary financial activities to ensure their adequate supply – non-standard policy measures take on a different character. They will embody elements of what Goodfriend (2011) calls 'credit policy' and thus have (quasi-)fiscal implications. Central banks need financial stability, functioning institutions, active markets and robust payment systems. In exceptional circumstances, they may have to engage in implicit subsidisation of these activities, so as to ensure monetary policy transmission and stabilise economic activity and price developments. Yet should the cost of such subsidisation grow to exceed the fiscal capacity of the central bank, persistently higher inflation over the longer term is the inevitable result. Given the difficulty of distinguishing between liquidity and solvency shocks in real time, recourse to such quasi-fiscal policy may be inadvertent, especially under the extreme pressure typically imposed on policy makers at times of financial crisis.

Experience during the recent financial crisis sheds light on these observations. Given the significant liquidity tensions that have characterised various phases of the crisis, central banks have responded strongly and rapidly by expanding their balance sheets to accommodate the private sector's revealed preference for liquidity. Our framework would support such an approach. And moreover, such balance sheet expansion would not pose in itself a threat to the maintenance of price stability. Additional non-standard measures – which support market functioning but extend beyond pure liquidity provision (e.g. implicit subsidisation of some activities or institutions by offering central bank facilities at favourable rates) – can also be justified on the grounds they support monetary policy transmission while being benign in terms of the outlook for steady-state inflation.

But – contrary to the view of some (what we would regard as complacent) observers – such actions are not devoid of risk. To the extent that observed liquidity problems reflect uncertainty about the underlying solvency of market participants (in the manner of Heider et al. (2009)), the provision of central bank liquidity may reduce the incentive for governments, regulators and/or the private sector to deal with the underlying fundamental problems, preventing a normalisation of market activity. Central banks may then be obliged to maintain their non-standard measures, creating the danger of dependency alluded to above. Moreover, the existence of these measures may promote destabilising behaviour even by sound institutions as moral hazard emerges. For example, prolonged use of non-standard measures may promote risk-taking by banks beyond levels they would consider appropriate in normal times, perhaps especially with regard to their financing of the public sector.[7] In turn, any implied softening of government balance

[7] This may take for instance the form of a commitment by commercial banks to finance the public sector over a long

sheet constraints - through e.g. rising bailing out of financial institutions by the central bank - can promote non-Ricardian fiscal behaviour. Although outside the scope of our model, such considerations point to self-sustaining dynamics in the quasi-fiscal activities of the central bank, increasing the risk that "fiscal dominance" over the price level ultimately emerges. The stakes are therefore high.

7 Further considerations: a non-inflationary limit to quasi-fiscal activities

The aforementioned considerations point to the essential intermediation role played by the central bank in the redistribution of financial resources between lenders and borrowers in crisis times. More risks that a central bank takes in its intermediation role, higher are the potential losses that it may face in the long run, eventually subject to its 'creditworthiness' in order to preserve its credibility as regards its ability to deliver its policy objective (price stability for most central banks in the world). With respect to the two views according to which the central bank's creditworthiness can be derived (namely from its ability to issue monetary liabilities or from a fiscal backing of its capital as discussed in Section 2), it is most likely that a sequential combination of both views will materialise in practice, unless the central bank is ready to use the inflation tax to finance its losses beyond its financial resources (past profits located in capital and reserves and current and future monetary income). This could be especially the case for central banks claiming their independence, which may encourage governments to consider their fiscal backing responibility vis-à-vis their own central bank as irrelevant.

Then comes the question of how large can the non-inflationary threshold of quasi-fiscal activities by the central bank be (i.e. what is the upper (non-inflationary) limit in Regime 3 discussed in Section 5). The simplest way to have a rather accurate proxy of potential financial resources of central banks over time is to estimate a net present discounted value of current and future seigniorage income, S. Following Buiter (2010), and by assuming a long-run currency demand function of the type:

$$\frac{M}{P} = kY^{\alpha}e^{-\beta\left(i-i^{C}\right)}$$

with $k, \alpha, \beta > 0$, this value can be approximated by the following reduced equation:

$$S = \left(\frac{1+i}{1+i-(1+\pi)(1+\gamma)^{\alpha}}\right)\left((1+\pi)(1+\gamma)^{\alpha}-1\right)M_0$$

which reveals to say that the profits of the central bank over its life is a function of the future inflation

period of time indexed to short-term interest rates.

rate, π, a future nominal discount rate, i, and the future growth of real GDP, γ, when π, i, γ and the future growth rate of the stock currency (equal to demand of currency), μ, are all constant.[8]

In theory, the room of manoeuvre of central banks based on the capitalisation of future monetary income can be very large as the net present discounted value of current and future seigniorage income, S, may potentially reach very high levels under reasonable assumptions for π, i and γ. When assuming for example $\gamma = 1\%$, $\pi = 2\%$ and $i = 4\%$, the net present discounted value of current and future seigniorage income would oscillate between respectively EUR 1.4 (when $\alpha = 0.5$) and 2.5 trillion (when $\alpha = 1$) for the ECB, between USD 1.5 (when $\alpha = 0.5$) and 2.7 trillion (when $\alpha = 1$) for the US Federal Reserve, between GBP 67 (when $\alpha = 0.5$) and 122 billion (when $\alpha = 1$) for the Bank of England and between JPY 142 (when $\alpha = 0.5$) and 259 trillion (when $\alpha = 1$) for the Bank of Japan for a given initial level of money stock.[9]

Although the room of manoeuvre of central banks - hence reducing the concerns implied by Regime 3 (discussed in previous sections) - appears very large from this calculation, these estimates must be relativised in light of three main risks. First, it is worth recalling that this net present discounted value of current and future seigniorage income is the maximum (expected) amount of money that the central bank may hope to accumulate over its entire life. This money can therefore be used only once to have non-inflationary implications from quasi-fiscal activities by the central bank, which may not be necessarily understood by fiscal authorities. For instance, governments may reasonably expect similar accomodative behaviour by the central bank in all future crisis situations. Second, there is always the risk of intertemporal mismatch between agents' behaviour and initial over-optimistic assumptions (making the expected figures irrealistic in practice) when calibrating current central bank's actions on future profits. In this regard, it is worth underlying the high sensitivity of results to the initial values chosen for the parameters π, i, γ and α, which is reflected by the relative large size of intervals reported above. Third, although being very impressive numbers in absolute terms, these estimates of the net present discounted value of future seigniorage do not appear so large in front of the figures related to public finances in the respective countries. For example, the level of net general government debt was about EUR 6.32 trillion

[8] As discussed in Buiter (2010), S can indeed be seen as the central bank's profits made through the interest saved by the central bank due to its ability to issue monetary liabilities, i.e. the difference between the market interest rate to be paid (in the absence of this ability), i, and the interest rate on holding currency (which is generally considered to be close to zero). In theory, $S = \left(\frac{1+i}{i-\mu}\right)\mu M_0$ which leads to the above equation when $1+\mu = (1+\pi)(1+\gamma)^{\alpha}$ as discussed in detail in Buiter (2010).

[9] An alternative and more simplistic version of the net present value would assume that banknotes would expand in proprtion of activity growth rate and that the interest rate reflects both the inflation target of the central bank and potential output. In this case, the above equation could be reduced to $S = \frac{i(1+\mu)}{i-\mu}M_0$. This reduced form provides similar estimates.

in the euro area (with a structural deficit of EUR 305.54 billion), USD 11.02 trillion in the US (with a structural deficit of USD 1,279.54 billion), GBP 1.15 trillion for the UK (with a structural deficit of GBP 103.01 billion) and JPY 612.59 trillion in Japan (with a structural deficit of JPY 41,489.10 billion) at the end of 2011 accroding to the IMF.[10] The importance of these three considerations appear even more relevant when taking into the political economy that may be at stake in practice.

On the one hand, acting once may implicitly be interpreted as a permanent commitment to intervene in the middle of any sudden crisis for which governments may not be prepared. The argument here would be that, by having the privilege of issuing money, the reactiveness of central banks is usually higher than that of governments (which have to go through national Parliaments to vote extraordinary budget). While in the central bank's view its should only allow governments to organise themselves for a more long-term and structural answer to the crisis (i.e. the 'buy-time'argument), this may not necessarily be understood in this way by governments. Alternatively, although governments may have good intentions when coordinating with the central bank, unexpected and urgent developments may relax their commitment to take over the quasi-fiscal activities performed by the central bank. Put it differently, quasi-fiscal activities by the central bank may simply reduce the incentives of governments to behave in a Ricardian-fiscal manner. In such a situation, financial risks for the central bank are potentially very high since intervening for one public agent (or state) may be seen as an implicit commitment to intervene for all when needed. This latter consideration is even more striking within a monetary union with autonomous and decentralised fiscal policies like in the EMU (due to the 'fair-treatment' argument). On the other hand, the possible gap that may exist in reality between the optimal inflation rate (based on a Laffer curve of seigniorage) and that compatible with the central bank definition of price stability (on which it based its credibility over time) may temporarily increase pressure from fiscal authorities on central bank to increase further its quasi-fiscal activities in the short run.

All these elements tend thus to suggest that the possible one-shoot (upper) limit for non-inflationary quasi-fiscal activities by the central bank (as suggested by Regime 3) would be not respected in practice. In particular, the time horizon by which the governments should take over the temporary quasi-fiscal activities of the central bank may become vague and weakly binding over time, which may eventually make its occurence less likely. This will inevitably increase moral hazard on the governments'side as they

[10] According to the same source, these numbers should jump respectively to EUR 7.64 trillion in the euro area (with a structural deficit of EUR 194.33 billion), USD 16.12 trillion in the US (with a structural deficit of USD 1,008.60 billion), GBP 1.46 trillion for the UK (with a structural deficit of GBP 21.06 billion) and JPY 852.92 trillion in Japan (with a structural deficit of JPY 38,681.30 billion) by the end of 2016. See IMF (2010), *World Economic Outlook - Tensions from the Two-Speed Recovery: Unemployment, Commodities, and Capital Flows*, April.

may appear today more concerned to finance other public expenditures, hence reducing in turn their future financial capacity, hence making their commitment to take over the quasi-fiscal activities by the central bank not credible in practice.[11] Consequently, the abovementioned considerations tend to suggest that the solution of the model described in the previous section is likely to move from Regime 3 to Regime 2 in practice where the equilibrium for the inflation rate would permanently remain above the target set by the central bank. This naturally decreases the desirability of testing (even temporarily) Regime 3 in practice as it may lead quickly to a loss of control over the central bank balance sheet, and hence unstable inflation rates not compatible with price stability definition.

8 Concluding remarks

To meet the challenges of the recent financial crisis, central banks have acted promptly, decisively and flexibly, using both standard and non-standard monetary policy measures. We view these two initiatives as complementary: standard measures (i.e., decisions on the level of official interest rates) remain focused on the maintenance of price stability, whereas non-standard measures (i.e., innovations in liquidity management and central bank operational procedures and practices) are geared towards supporting market functioning and maintaining monetary policy transmission, such that the monetary policy stance designed by the standard measures are effectively transmitted to the broader economy.

An important aspect of the central banks' response has been accommodation of the private sector's heightened demand for liquidity. On the basis of our analysis (and in line with existing literature), such accommodation is both socially desirable and costless in terms of central bank objectives. Our framework also allows a case to be made for the introduction of a broader set of non-standard central bank policy measures, extending beyond pure liquidity provision. In exceptional circumstances (and when no alternative sources of support are available), central banks may have to sponsor crucial financial activities through quasi-fiscal means – what Goodfriend has labelled 'credit policy' – so as to ensure monetary policy transmission and thereby maintain the ability to stabilise economic activity and price developments in the face of cyclical shocks. The case for non-standard measures is therefore strong.

But introducing such a broader set of measures is not without risks, even if they have no immediate effect on the steady-state rate of inflation and are thus consistent with central banks' pursuit of price stability. Unless limited in scope and/or duration, such measures may facilitate fiscal dynamics that, in

[11] In the same vein, governments may be tempted to transfer new task and responsibilities to the central bank which should normally be on their budget. In this case, the related risks for the central bank may not only be reputational as argued in Issing (2012) but also financial.

general equilibrium, imply an undesirably high steady-state rate of inflation, inconsistent with the central bank mandate to maintain price stability. These risks are particularly acute when the broader fiscal environment is unfavourable – when the outstanding stock of public debt is high; the government deficit is large; and the tax base is small or shrinking. And such risks are exacerbated if the non-standard measures weaken incentives for fiscal rectitude or private sector restructuring. By relaxing constraints on other economic actors, central bank support may create opportunities for them to shirk their responsibilities. In turn, this may render it more difficult for the central bank to withdraw its exceptional measures. What was initially intended as (benign) temporary liquidity support may (potentially inadvertently, as private or government behaviour evolve) morph into (malign) persistent and growing solvency support. Moreover, by acting in a such way, central banks take the risk of creating a precedent which may prove difficult to unwind in any future crisis. This would imply a lasting drain on central banks' financial independence and credibility, to the detriment of their pursuit of price stability. The road to a central bankers' hell may be paved with good intentions.

In short, non-standard central bank measures have to be designed with exit in mind. And such considerations must entertain not only the exogenous or technical elements of exit (such as the maturity of operations or the duration of special facilities), but also the endogenous elements stemming from the impact of the measures themselves on other economic actors' incentives and behaviour. However, in the midst of financial crisis when the short-term pressures on policy makers threaten to become overwhelming, the danger exists that these longer-term risks are neglected. In this context, it will be critical to recognise that, to the extent that the underlying causes of the financial crisis are real in nature, monetary policy cannot remedy them. Non-standard monetary policy measures may treat the immediate symptoms. And this is not something to be dismissed lightly at moments of financial stress. But ultimately only governments and/or the private sector can cure the fundamental problems, since they are the ones with a call on real economic resources.

Central banks therefore have to steer a difficult course between Scylla and Charybdis. On the one hand, an inadequate immediate response to the emergence of market tensions risks disruption to monetary policy transmission and a destabilisation of the economy by cyclical shocks. But, on the other hand, if the scope and duration of such non-standard responses are not appropriately limited, risks to price stability over the medium term may emerge. As we have seen, conducting monetary policy in an environment of financial crisis is therefore a far from easy task.

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9 Annex

9.1 Private sector

9.1.1 Households

Solving the representative household's constrained optimisation problem described in the main text gives rise to the following Euler equation:

$$\frac{\eta}{\overline{m}} \; L_m \left(\frac{m_t}{\overline{m}} \right) \quad = \quad u_{c,t} \; \frac{(R_t - i_t)}{R_t}$$

Using the definitions in the main text, this gives rise to the expression

$$\frac{\eta}{\overline{m}} \; L_m \left(\frac{m_t}{\overline{m}} \right) \quad = \quad u_{c,t} \; \mu_t$$

and in turn the demand for reserves

$$m_t \quad = \quad m \; (c_t, \; \mu_t; \; \overline{m}, \; \eta)$$

with

$$m_{c,t} \quad = \quad \frac{\overline{m}^2 \; \mu_t \; u_{cc}(c_t)}{\eta \; L_{mm} \left(\frac{m_t}{\overline{m}} \right)} \quad > \quad 0$$

$$m_{\mu,t} \quad = \quad \frac{\overline{m}^2 \; u_c(c_t)}{\eta \; L_{mm} \left(\frac{m_t}{\overline{m}} \right)} \quad < \quad 0$$

$$m_{\eta,t} \quad = \quad \frac{- \; \overline{m} \; L_m \left(\frac{m_t}{\overline{m}} \right)}{\eta \; L_{mm} \left(\frac{m_t}{\overline{m}} \right)} \quad > \quad 0$$

$$m_{\overline{m},t} \quad = \quad \frac{1}{L_{mm} \left(\frac{m_t}{\overline{m}} \right)} \; \left[\frac{L_{mm} \left(\frac{m_t}{\overline{m}} \right)}{\overline{m}} \quad + \quad \eta \; L_m \left(\frac{m_t}{\overline{m}} \right) \right]$$

and

$$m \; (c_t, \; 0; \; \overline{m}, \; \eta) \quad \geq \quad \overline{m}$$

9.1.2 Firms

[*to be added*]

9.2 The central bank

On the basis of the central bank balance sheet and income relationships discussed in the main text and the definition of the spread between the market rate and the rate at which the central bank remunerates reserves, one obtains:

$$\psi_t \;=\; R_{t-1}\;\mu_{t-1}\;\frac{m_{t-1}\;p_{t-1}}{p_t} \;=\; R_{t-1}\;\frac{p_{t-1}}{p_t}\;\mu_{t-1}\;m(c_{t-1},\;\mu_{t-1};\;\overline{m},\;\eta) \;\geq\; 0$$

Consider a central bank that seeks to maximise its seignorage revenue (for a given level of consumption, which is determined by real considerations). Its solution to the problem would derive from the first order condition:

$$\psi_{\mu,t} \;=\; R_{t-1}\;\frac{p_{t-1}}{p_t}\left[\mu_{t-1}\;\frac{\overline{m}^2\;u_c(c_{t-1})}{\eta\;L_{mm}\left(\frac{m_{t-1}}{\overline{m}}\right)}\;+m_{t-1}\right] \;=\; 0 \quad\Longrightarrow\quad m_{t-1} \;=\; -\mu_{t-1}\;\frac{\overline{m}^2\;u_c(c_{t-1})}{\eta\;L_{mm}\left(\frac{m_{t-1}}{\overline{m}}\right)}$$

To check that this is indeed a maximum, the second order condition must be satisfied:

$$\psi_{\mu\mu,t} \;=\; R_{t-1}\;\frac{p_{t-1}}{p_t}\;m_{\mu,t-1}\;\left[2-\frac{\overline{m}\;u_c(c_{t-1})}{\eta}\,\frac{L_{mmm}\left(\frac{m_{t-1}}{\overline{m}}\right)}{\left[L_{mm}\left(\frac{m_{t-1}}{\overline{m}}\right)\right]^2}\right] \;<\; 0$$

which will hold under the regularity condition

$$\frac{L_{mmm}\left(\frac{m_{t-1}}{\overline{m}}\right)}{\left[L_{mm}\left(\frac{m_{t-1}}{\overline{m}}\right)\right]^2} \;<\; \frac{2\eta}{\overline{m}\;u_c(c_{t-1})}$$

which is assumed to hold.

In that case, we can define a seignorage maximising level of reserves m^*_{t-1}, which satisfies the FOC. From the FOC, $m^*_{t-1} > 0$. From $m(c_{t-1},\;0;\;\overline{m},\;\eta) = \overline{m}$ and the definition of seinorage, $m^*_{t-1} < \overline{m}$.

$$0 \;<\; m^*_{t-1} \;<\; \overline{m}$$

Associated with this revenue-maximising level of reserves are: (i) a revenue maximising level of the central bank spread, μ^*_{t-1}; and (ii) a maximum level of seignorage income, $\psi^*_t = \psi^*(c_{t-1};\;\overline{m},\;\eta)$.

FIGURES

FIGURE 1 – EVOLUTION OF THE SIZE OF CENTRAL BANK'S BALANCE SHEET

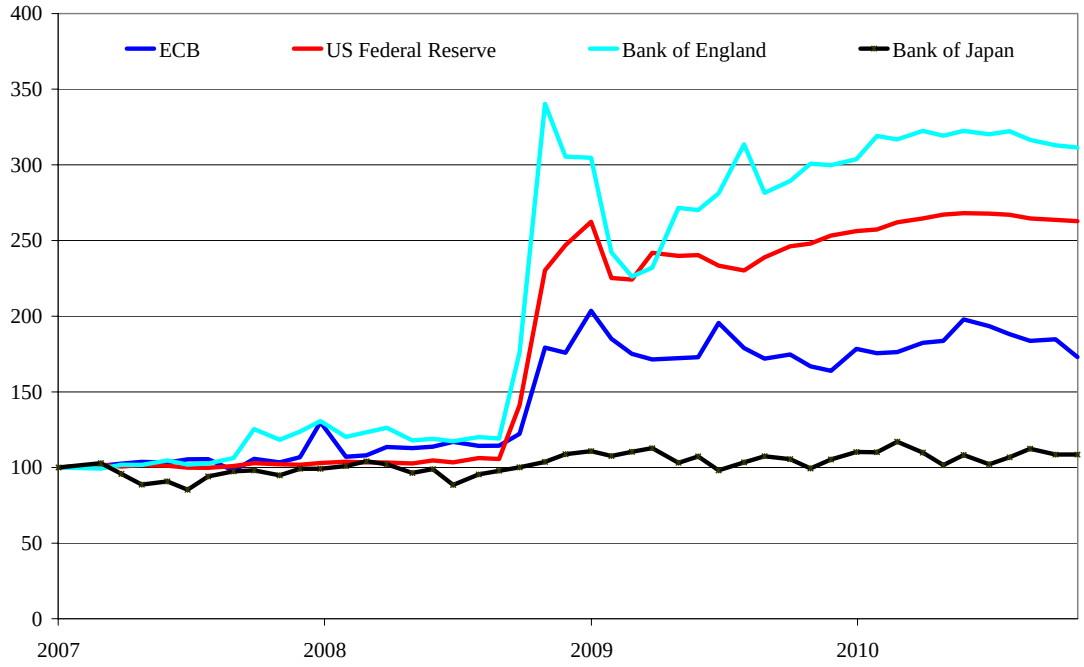
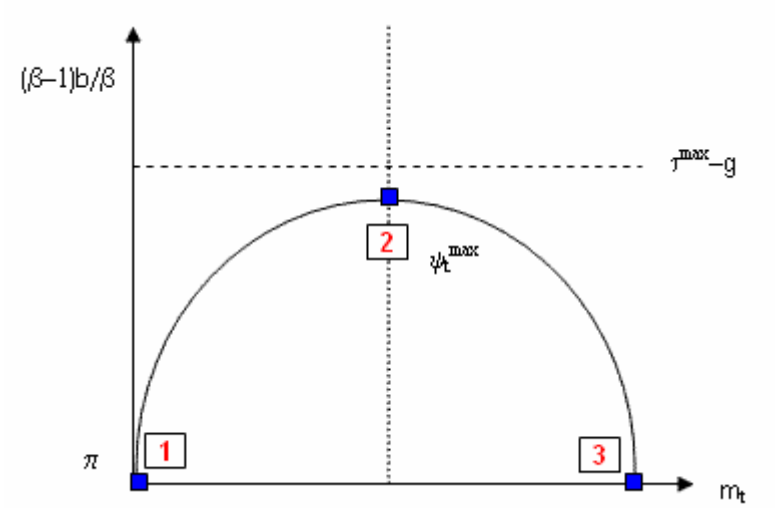
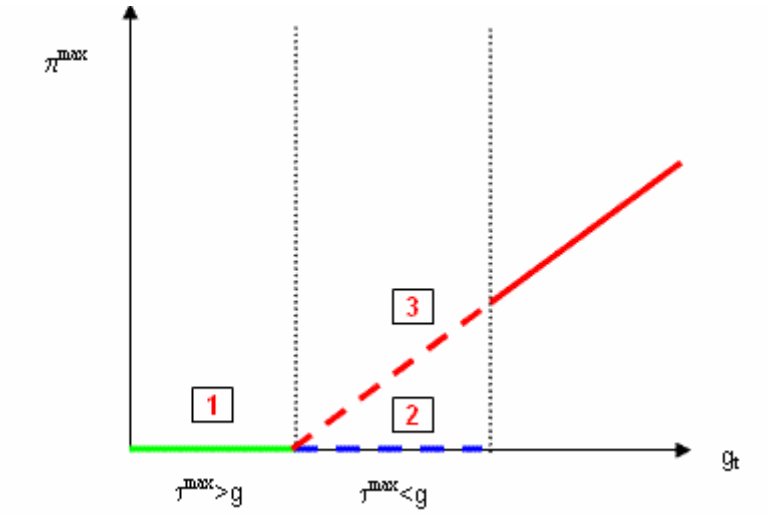


FIGURE 2 – IMPACT OF VARIOUS REGIMES ON SEIGNORIAGE AND INFLATION



PANEL A – EVOLUTION OF SEIGNORIAGE FOR A GIVEN LEVEL OF REAL DEBT



PANEL B – EVOLUTION OF INFLATION FOR A GIVEN LEVEL OF TAXES

FIGURE 3 – INFLATION OUTCOME FOR VARIOUS LEVELS OF τ AND g