Rethinking Monetary Policy After the Crash

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1. Introduction

It is widely recognized that the global financial crisis led central banks around the world to reformulate strategy in several ways. The *conventional* monetary policy tool, typically an overnight interbank interest rate, was brought to virtually zero in many advanced countries. Searching for additional stimulus, central banks in those countries resorted to *unconventional* weapons, baptized with names such as *quantitative easing* and *forward guidance*. Central banks have been charged not only with managing inflation and ensuring full employment, but also with seeking financial stability, supervising and regulating financial intermediaries, and preventing financial imbalances and asset price bubbles via suitable macroprudential measures.

This represents a dramatic turnaround. As late as 2007, a consensus had developed around the "best practice" framework for monetary policy: inflation targeting (IT). IT had been credited with the conquest of inflation in practice. And, in addition, IT had been found backing by an elegant and consistent theory: the New Keynesian model, as exposed in the Woodford (2003) and Gali (2008) textbooks. So, Goodfriend (2007) summarized this state of affairs by writing:

> ... the world achieved a working consensus on the core principles of monetary policy by the late 1990s... The consensus theory of monetary policy... implies that inflation targeting yields the best cyclical behavior of employment and output that monetary policy alone can deliver.

In this paper I attempt to provide a perspective on how and why the financial crisis shattered the consensus, and how the latter might be restored. While the considerations are many and complex, my discussion will revolve around the interplay between events, policy, and theoretical research as a main theme. More specifically, the story line is that the financial crisis and the policy response exposed a main shortcoming of the textbook New Keynesian model: its assumption of perfect, frictionless financial markets. This assumption had very strong implications which, given recent events, now appear quite unappealing. For example, it implies that quantitative easing is irrelevant, and that financial intermediaries are superfluous (as the Modigliani-Miller theorem holds). Hence the New Keynesian model is being reformulated in various ways, in order to accommodate financial frictions and financial intermediation and, ex post, to explain how unconventional policies, financial regulation, macro prudential measures, and the like, interact

in shaping aggregate fluctuations. *Ex post,* such a research effort may restore the theoretical underpinnings of inflation targeting. But it is too early to say if there will be success in that regard, and also to envision how IT will have to be reformulated for a new consensus to take hold.

In developing the main theme I will touch on several other topics along the way, especially issues associated with open economies. This is because we may benefit from thinking about how those topics fit into the overall picture and also because a conflict between IT theory and practice had appeared earlier in some emerging countries (see Chang 2007 for a review of Latin American cases).

2. Monetary Policy, Inflation Targeting, and the New Keynesian Model

2.1. The Consensus, Circa 2007

As mentioned, prior to the onset of the global financial crisis, inflation targeting (IT) had attained the status of "best practice" framework for the analysis and conduct of monetary policy. As stated by Svensson (2007, and others), Agenor and Pereira da Silva (2013), and several others, an IT targeting regime is characterized by (i) an announced numerical inflation target; (ii) an explicit decision making framework determining how policy instruments are adjusted in order to hit the target; and (iii) a high degree of transparency and accountability.

Several comments are in order:

- In the typical IT scheme, the numerical target for inflation mentioned in (i) is assigned to the central bank by the executive or the legislature. Hence the central bank is not "goal independent". On the other hand, the central bank is "instrument independent", in the sense that it is free to adjust any policy tool at its disposal to attain its targets.

- Instrument independence, however, is constrained by (ii) and (iii). In particular, an IT central bank has to explain how the setting of policy instruments is expected to affect the forecast of inflation and other possible target variables. And it has to do so in the context of an "explicit decision making framework".

- In practice, the main policy tool has been an interest rate, often an overnight rate in the interbank market. In this, policymakers may have followed the

lead of the U.S. Federal Reserve and other advanced country central banks. But also, as discussed below, this choice may have reflected the theoretical underpinnings of the IT approach, which provide an explicit account of the links between the policy rate and the ultimate goals of policy.

- An IT central bank can be assigned goals other than inflation (in whose case the regime is called "flexible IT"; IT is called "strict" if inflation is the central bank's only goal). In practice, such additional goals have been related to full employment and growth.

It is worth emphasizing the contrast between IT and other possible monetary frameworks. One alternative has been to assign the central bank some goals, such as "price stability" or "full employment", without a commitment to numerical targets; the U.S. Federal Reserve is a case in point. Another alternative has been for a central bank to announce targets for variables other than inflation, notably the exchange rate (as in fixed exchange rate regimes) or a monetary aggregate (e.g. a target for base money growth).

The ascent of IT as a dominant monetary framework is partly explained by its apparently favorable impact in practice. Indeed, the adoption of IT by several central banks coincided with a noticeable fall in inflation rates. Econometric studies also provide some evidence that, on the whole, favor the view that IT is associated with lower, less persistent, and less volatile inflation (Agenor and Pereira da Silva 2013, section 4, provide a nice survey).

But the acceptance of IT was also linked to the development of a suitable "explicit decision making framework". By and large, this framework was given by the New Keynesian approach to macroeconomics. For our purposes, it will be useful to summarize this connection.

The New Keynesian model (NK model hereon), as described by Clarida, Gali and Gertler (1999), Woodford (2003), or Gali (2008), extends the canonical stochastic optimal growth model to include nominal price rigidities and, therefore, a role for monetary policy. In order to introduce nominal rigidities, the model assumes the existence of price setting producers, and hence imperfect competition. As a consequence, in a laissez faire competitive equilibrium, production is suboptimally low on average. In addition, price setting and monopolistic competition can lead to price dispersion and inefficient departures from the Law of One Price.

Three crucial implications of the basic NK model are particularly relevant. First, aggregate supply is described by the so called *New Keynesian Phillips Curve*, which to a first order approximation can be written as:

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t \tag{1}$$

where π_t is the inflation rate, $E_t\pi_{t+1}$ expected future inflation, y_t the output gap (the log difference of actual output and natural output, the latter defined as the output level that would obtain in the absence of nominal rigidities), and β and γ are coefficients that depend on the various parameters of the model.

Second, under some auxiliary assumptions, a second order approximation to the welfare of the representative agent can be written as the expected present discounted value of a *loss function* that depends only on inflation and the output gap:

$$E\sum_{t=0}^{\infty}\beta^t L_t = E\sum_{t=0}^{\infty}\beta^t\left[\pi_t^2 + \varphi y_t^2\right] \tag{2}$$

where L_t is the current loss and φ, the weight of output relative to inflation in the loss function, depends on basic model parameters.

Third, the aggregate demand side of the model is described by an *IS curve* of the form

$$y_t = -\rho\left[i_t - E_t\pi_{t+1} - r_t^n\right] + E_t y_{t+1} \tag{3}$$

where ρ is a parameter, ι_t is the short term nominal interest rate and r_t^n is the *natural real rate of interest* (the real rate in the absence of nominal rigidities), which is a function of exogenous shocks.

These results lead to a framework for monetary policy that (perhaps strikingly) corresponds quite closely to flexible IT. In the New Keynesian setting, optimal monetary policy is given by the maximization of the aforementioned loss function (2) subject to the New Keynesian Phillips Curve (1) and the IS curve (3). This resembles flexible IT in that it is optimal for the central bank to be charged with the minimization of a loss function that depends on inflation and the output gap as targets.

Thus the NK model became the theoretical foundation for IT. But the basic version of the model also suggested more specific prescriptions, of which the following ones are of particular relevance for our discussion:

- The basic NK model not only rationalized the traditional view that the monetary authority should minimize a quadratic loss function that depends on inflation and the output gap. It also says that the social loss function can be written as a function of *only* those two variables. Hence the basic NK model did not provide support for the view that central banks should

be charged with additional goals, such as ensuring financial stability or minimizing exchange rate volatility.

- In the basic NK model the interest rate can be taken as the only policy instrument needed to maximize social welfare. To see this, assume that a policy rule of the Taylor type, say

$$i_t = \alpha\pi_t + \mu y_t \tag{4}$$

  is given. Then this rule, together with the IS curve and the Phillips curve, generally suffice to determine the stochastic processes for inflation, the output gap, and the interest rate, and therefore the expected social loss. More generally, welfare maximization involves finding an appropriate policy linking the interest rate to the target variables (inflation and the output gap). Notably, this implies that control of the interest rate suffices to implement an optimal policy: there is no need for the monetary authority to resort to other "unconventional" policy instruments.

- As emphasized by Svensson (2007), the minimization of the loss function (2) subject only to the New Keynesian Phillips Curve (1) results in a system of dynamic first order conditions of the form $G_t(\pi_t, y_t, E_t\pi_{t+1}, E_t y_{t+1}, ...)$. This system suffices to determine the optimal current and expected settings of the target variables, in this case inflation and the output gap. Then the IS equation (3) yields the appropriate setting for the nominal interest rate to implement the desired path. Hence an optimal monetary strategy involves what Svensson calls "inflation forecast targeting".

- The argument in the preceding paragraph also has a stark implication for the variables that an optimal policy rule should react to: the policy instrument should be adjusted in response to information that affects the current and future expected values of *target* variables. Hence, it may be advisable to adjust the policy interest rate in response to news in *non-target* variables, such as credit spreads. But this is only warranted to the extent that such news have predictive power in expected future inflation and the output gap.

- Finally, in the above version of the NK model a zero inflation target is optimal. This is because the New Keynesian Phillips Curve (1) implies that stabilizing inflation at zero also means stabilizing the output gap at zero, this minimizing the loss function. This has been called "divine coincidence" by Blanchard and Gali (2007) and others.

Much research in the previous decade was devoted to investigating whether these implications were essential to the NK model or, instead, side effects of the simplifying assumptions imposed in the basic version of the model. If the latter, the literature focused on how more general assumptions led to modifications of the policy prescriptions. The hope was that such modifications turned out to be minor in cases of practical interest, but this had to be conformed by examining the associated model extensions. Accordingly, we turn to three extensions that received particular attention in the literature.

2.2. Three Elaborations Within the Paradigm

2.2.1. Cost Push Shocks

Suppose that there are shocks to aggregate supply, captured by an additive term (say an exogenous i.i.d. process u_t) in the New Keynesian Phillips Curve:

$$\pi_t = \beta E_t \pi_{t+1} + \gamma y_t + u_t$$

One immediate implication of such *cost push* shocks is that zero inflation does not imply a zero output gap. The "divine coincidence" is then gone, and the monetary authority faces a genuine tradeoff between inflation and output.

Cost push shocks may emerge for several reasons (e.g. variations in desired markups, which may occur because of changes in the elasticity of substitution between imperfectly competitive goods) and, as mentioned, result in a more complicated policy problem. However, the complications are mostly technical in nature. In this sense, cost push shocks do not fundamentally alter the basic monetary framework suggested by the New Keynesian approach.

In a different sense, however, the introduction of cost push shocks drew attention to a fundamental problem: the *time inconsistency* of optimal monetary policy. The basic optimal policy problem described in the previous subsection assumes that the monetary authority can initially commit to a time and state dependent policy. But if the monetary authority can re-optimize at some future date, it will generally choose to depart from the original policy. In this sense, the optimal policy is not *credible.*

Since the original studies of Calvo (1978) and Kydland and Prescott (1982) a large literature has been devoted to study the time inconsistency problem and propose "solutions". A satisfactory resolution has been, however, elusive. As a consequence, most papers in the NK tradition have ignored the issue and restricted the analysis to the case of perfect commitment.

It must be said, however, that inflation targeting has been proposed in fact as a way for the central banker to solve the credibility problem. The assumption has been, effectively, that the central bank can commit to simple rules, such as Taylor rules like (4). Advocates of this view point out that, empirically, IT has been found to butress the credibility of central bank announcements of inflation. On the other hand, reconciling this view with a consistent model of monetary policy decision making remains an open question.

2.2.2. The Zero Lower Bound, Unconventional Policy, and Financial Markets

Another pesky issue is given by the fact that nominal interest rates cannot be negative, a restriction that can prevent the implementation of otherwise optimal allocations. To see how this can occur, consider again a policy intended to deliver zero inflation at all times. In the absence of cost push shocks, the Phillips Curve (1) delivers a zero output gap at all times, and then the IS curve (3) requires the nominal interest rate i_t to be equal to the natural real rate r_t^n . But the latter can be negative, at least some times. It follows that the purported policy implies that the nominal interest rate violates the *zero lower bound (ZLB)*, and hence it is not feasible.

The ZLB problem emerged as a main policy concern at the turn of the millennium, to a large extent in response to Japan's long period of recession and price deflation. Krugman (1998) forcefully emphasized that expected deflation, a main feature of the Japanese experience, could result in a damagingly high real rate of interest even if the nominal interest rate was cut to zero. If that was the case, Krugman argued, monetary policy had reached its limits, so expansionary fiscal policy became essential. An alternative solution may have been to try to engineer expectations of inflation instead of deflation. However, Krugman pointed out, announcements of future inflation in Japan may not have been credible, given its history and the Bank of Japan demonstrated aversion to inflation.

The practical importance of this problem became apparent, of course, during the global crisis of 2007-8, as major central banks cut their policy rates to virtually zero. At this point, and faced with the need to provide further monetary stimulus, the U.S. Federal Reserve and several others resorted to policies that have been collectively termed *unconventional.* These include:

- *Quantitative Easing (QE):* central bank purchases of government bonds of different maturities, aimed at lowering yields and twisting the term structure

of interest rates.

- *Credit easing (CE):* central bank operations to increase the flow of credit to the private sector, either by providing extra liquidity to financial intermediaries (*indirect credit easing*) or by directly purchasing private securities such as mortgage backed ones (*direct credit easing*).

- *Forward guidance:* Announcements promising that interest rates will be kept low for a relatively long time, and linking the end of this stance to indicators of recovery, particularly the unemployment rate.

The ZLB issue and unconventional policy responses represent an important challenge to the basic Kew Keynesian model. There is, of course, the practical question of whether unconventional policies have had a significant impact, and whether the impact is consistent with the New Keynesian model.

But there is also a more fundamental issue, especially for the evaluation of QE and CE policies. For analytical convenience, the basic NK model assumed the existence of perfect and complete financial markets. But this assumption easily implies the irrelevance of many QE and CE operations, such as rearrangements of a central bank portfolio. This is because perfect financial markets guarantee the validity of theorems of the Ricardian type. This was first observed by Wallace (1981), who showed conditions under which open market operations are irrelevant, and developed by Eggertsson and Woodford (2003), who extended Wallace's results to a stochastic environment and, importantly, showed the results to be immune to the existence of the ZLB.

One interesting solution to this conundrum has been to assume (realistically) that central bankers cannot commit to honor their promises, so that announcements of high inflation may be time inconsistent. In this case, it can be shown that a rearrangement of the central bank portfolio can deter the central banker from reneging on such announcements (Jeanne and Svensson 2007). The intuition is that, even if the central bank portfolio is irrelevant in equilibrium, the portfolio may lose value if the central bank reneges and deviates from the equilibrium. The argument is thus similar to that of Lucas and Stokey (1983) for the relevance of the term structure of government debt and, interestingly, suggests that quantitative easing may be necessary to ensure the credibility of forward guidance.

While the preceding argument has had some practical impact, the literature has largely accepted the need to drop the assumption of perfect financial markets in order to evaluate unconventional policies and their interaction with the ZLB.

This is of course natural, given the prominent role of financial phenomena in the recent global crisis, but represents a radical departure from the basic New Keynesian model. We discuss some aspect of this departure in later sections.

2.2.3. The Open Economy and the Terms of Trade Externality

The basic NK model assumes a closed economy whose key distortion is nominal price rigidities. This leads to inefficient markup fluctuations and price dispersion, which are costly in terms of welfare, and explain why price stability emerges as a main policy prescription. Open economies typically provide a second distortion that can be affected by monetary policy: the so called *terms of trade externality*, first discussed by Corsetti and Pesenti (2001). The intuition is that monetary policy can affect the world relative price of home produced goods. Optimal policy then requires taking advantage of that margin, in addition to addressing the distortions due to rigidities in domestic price setting.

In principle, the existence of the terms of trade externality may help rationalizing the fact that monetary policy in open economies often reacts to exchange rate developments, even in countries that have adopted inflation targeting. Di Paoli (2009), in particular, extended the New Keynesian small open economy framework of Gali and Monacelli (2005) and showed that a second order approximation of the representative agent could be written as a present discounted value of expected losses, as in (2) above, except that the loss function had to be amended to include the real exchange rate, in addition to inflation and the output gap. A fortiori, this implies that it is desirable for monetary policy to react to the real exchange rate.

The quantitative importance of this argument, however, is still under debate. Gali and Monacelli (2005) and Gali (2008) paid special attention to a parameterization that implied that stabilizing domestic producer prices, the optimal policy in a closed economy, is also optimal in the open economy. Di Paoli (2009) examined other parameterizations numerically and argued that, while PPI stabilization was generally suboptimal, it was almost optimal for realistic parameter values.

The model of Gali and Monacelli (2005) and Di Paoli (2009) is quite special, for example in that it assumes a world of identical countries. In reality, of course, countries differ in many respects, such as their structure of production and the commodities they export or import. Thus, in particular, fluctuations in world relative prices may impact different countries to varying degrees, and require different policy responses. This issue has received special attention recently in light

of the increased volatility in world commodity prices. One consequence is a revival of the debate on the importance of the terms of trade externality and its determinants.

As emphasized by Catao and Chang (2013), the quantitative magnitude of the terms of trade externality generally depends on a variety of parameters, such as elasticities of substitution in demand. But it also depends on assumptions about international risk sharing and financial markets. This link has been missed by much of the literature, including Gali and Monacelli (2005) and Di Paoli (2009), which confines attention to the case of perfect international risk sharing. This consideration, therefore, also points to the need to include financial frictions explicitly into the analysis. We now turn to this issue.

3. Introducing Financial Frictions in Monetary Policy Models

3.1. Net Worth Effects in the New Keynesian Model

As emphasized, the basic NK model assumed away imperfections in financial markets, mostly for technical convenience. In so doing, it put aside a long tradition of emphasizing the macroeconomic impact of financial frictions.

In the context of modern dynamic macro models, this tradition was first formalized by Bernanke and Gertler (1989), which examined an overlapping generations economy populated by savers and entrepreneurs. The latter were assumed to be able to produce capital, financing investment with their own net worth as well as by borrowing from savers. Due to asymmetric information (the so called costly state verification problem of Townsend 1979 and Williamson 1986), the amount invested and the cost of capital turned out to depend on entrepreneurial net worth. This implied that the dynamics of the model were determined not only by capital accumulation but also by the evolution of net worth. In particular, as Bernanke and Gertler (1989) emphasized, this *financial accelerator* channel enhanced the amplification and persistence of shocks.

In terms of policy, Bernanke and Gertler (1989) successfully formalized several issues that had been elusive. Importantly, the paper showed how a negative shock to the balance sheet of entrepreneurs could result in a recession. This was the case even if the shock was a pure redistribution of wealth from entrepreneurs to savers, as might result from changes in relative prices.

The original Bernanke and Gertler (1989) model emphasized the influence of

financial frictions on macroeconomic dynamics, but its overlapping generations structure limited its application to monetary policy issues. The next milestone was Bernanke, Gertler, and Gilchrist (2000, henceforth BGG). Extending results from Carlstrom and Fuerst (1995), BGG adapted the original Bernanke-Gertler setting to a model populated by infinite horizon households and entrepreneurs, and introduced nominal rigidities in the usual Calvo-Yun fashion. This allowed for the examination of alternative monetary policies in realistic settings. Not much later, versions of BGG were being extended, estimated, and used to evaluate monetary policy issues (Christiano, Motto, and Rostagno 2004, for example).

While BGG was clearly a breakthrough in introducing financial frictions in a model useful for monetary policy, it is fair to say that it did not represent a direct challenge to the prevailing monetary policy framework. This was perhaps because BGG focused on the propagation of conventional shocks, such as ones to productivity. The financial sector, by itself, was not modeled as a new source of shocks. Then, by and large, the optimal policy problem was just a version of the one discussed before (versions of equations 1-3, with different coefficients). Intuitively, the financial frictions of BGG just amplified the impact of conventional shocks on aggregate demand. While this was expected to change the magnitude of the optimal monetary response, it did not alter that response qualitatively nor created a new tradeoff. Likewise, no need for alternative policy instruments emerged.

3.2. The Open Economy: Net Worth Effects, Dollarization, and Exchange Rates

Matters developed somewhat differently when financial frictions were added to NK models of the open economy. Well known events in emerging economies, especially those affected by the sequence of crises in the second half of the 1990s, motivated a heated debate on the costs and benefits of fixed exchange rates versus flexible rates. One argument in favor of fixed exchange rates (and, hence, against IT) was based on the observation that corporate entities in emerging economies had taken large amounts of debt denominated in foreign currency. This *dollarization* (or *currency mismatch*) issue meant that an exchange rate depreciation imposed a capital loss on corporate net worth which, assuming financial frictions of the BGG kind, resulted in increased agency costs and a drop in aggregate demand, output, and employment.

This argument was developed and clarified by Céspedes, Chang, and Velasco

(2004, henceforth CCV; see also Céspedes, Chang and Velasco 2002). In an open economy model, CCV showed that the combination of dollarized debts and balance sheet effects did indeed imply the contractionary effects of depreciation just mentioned. However, CCV also showed that this did not necessarily give the edge to fixed exchange rates. The balance sheet effect, CCV observed, is caused by movements in the *real* exchange rate, which are not eliminated under a system of fixed (*nominal*) rates. Indeed, CCV showed that targeting the producer price index (PPI) was optimal in their model.

For our purposes, CCV and the literature that followed were significant not only for allowing for balance sheet effects in the open economy, but also for demonstrating the optimality of IT relative to alternative policy frameworks (such as fixed exchange rates). In addition, this line of research resulted for early proposals of macroprudential policies, in particular in arguing for policies designed to actively reduce dollarization and currency mismatches.

On the other hand, just as BGG, CCV and related open economy papers did not mount a substantial challenge to IT as the dominant monetary framework. In fact, as mentioned, they added to the conventional wisdom that some combination of IT and flexible exchange rates were the best available choice for central bankers (see also Gertler, Gilchrist and Natalucci 2007, and Devereux, Lane and Xu 200x).

3.3. Asset Price Bubbles

One important although still imperfectly understood aspect of BGG and other models that emphasize net worth effects is that they provide a natural explanation of how bubbles in asset prices, such as real estate, can have destabilizing effects in the aggregate. Intuitively, bubbles that result in runaway asset prices raise net worth, decrease agency costs, and boost borrowing and aggregate demand as a consequence. A bursting bubble has the opposite effect, a recession.

Recognizing that bubbles might increase an economy's volatility, however, does not imply that the monetary framework has to be altered in response. In fact, Bernanke and Gertler (1999) argued that the usual IT framework was sufficient to deal with the existence of bubbles, the intuition being again that bubbles would lead to incipient increases in aggregate demand and inflation, automatically triggering a monetary response under IT.

The debate remained unsettled, however, reflecting to a large extent the absence of a satisfactory model of bubbles. In the absence of such a model, proposals to make monetary policy respond to incipient bubbles have faced a host of prac-

tical questions such as: How can one identify bubbles in practice? Assuming we can recognize a bubble is developing, how can the central bank deflate the bubble without causing major harm? Is the policy rate too blunt of an instrument to prick a bubble? These and other considerations gave the edge to those that argued in favor of "mopping up after the crash".

Of course, after the global financial crisis the balance moved in favor of more policy intervention aimed at preventing the emergence of bubbles. What kinds of intervention are warranted and how they affect the macroeconomic equilibrium remains, however, an open question.

4. Financial Intermediation and Monetary Policy

The global financial crisis, especially after the Lehman bankruptcy and the subsequent meltdown of finance worldwide, led to a search for innovative and untested policy alternatives, especially in advanced economies. This search has been the main motivation for much current research on monetary policy and central banking.

From this perspective, three aspects of the crisis and the policy response have been particularly influential:

- The crisis most severely affected financial intermediation, and the associated financial institutions and markets. The so called "shadow banking system" collapsed, and with it banks, the interbank market, and money markets were tested to the limit. (Brunnermeier 2009)

- Central banks in advanced countries drove their policy rates to the lower zero bound. This was deemed insufficient, partly because lower policy rates were not effective in lowering other interest rates, signaling that the transmission mechanism had broken down (Adrian and Shin 2009). To provide further stimuli, the U.S. Federal Reserve and other central banks resorted to other unconventional tools, such as new liquidity assistance facilities, QE and CE.

- In spite of the massive expansion of central banks' balance sheets and liquidity injection, it appears that credit to the private sector has not recovered, reflecting a deleveraging attempt by financial intermediaries.

As a reaction to these and other related considerations, recent research has focused on how best to introduce financial intermediation, institutions, and markets, into models useful for monetary policy evaluation. At the same time, such

models should allow for the study of unconventional monetary policy. Much of the current literature is engaged in this effort.

4.1. Introducing Financial Intermediation

As already noted, while BGG and others had successfully incorporated financial frictions and imperfections in dynamic models, including New Keynesian ones, they assumed that financial frictions affected the relationship between ultimate savers (households in the BGG model) and ultimate borrowers (entrepreneurs). While this relationship was mediated through financial intermediaries (coalitions of savers), they did not play a main role in those models (it only served to rationalize the assumption that lenders could diversify away idiosyncratic risk).

Recent events, however, suggest that financial intermediaries may play an essential role and, in particular, be themselves the sources of aggregate shocks. In addition, understanding unconventional policies aimed at assisting financial intermediaries in multiple ways (equity injections, asset exchanges, changes in reserve requirements) requires modeling financial intermediaries in a more satisfactory way.

Modeling financial intermediaries turns out to be a hard enterprise, however, especially if one attempts to embed financial intermediaries into dynamic stochastic models. Ideally, one would be able to spell out the reasons why intermediaries exist and choose assets and liabilities with particular characteristics. Banks, in particular, are often described as issuers of short term liquid liabilities (demand deposits) which are used to finance illiquid, long term assets. Explaining this from first principles requires making special assumptions about the economic environment. In the influential Diamond-Dybvig (1983) model of banks, for example, agents can invest in a low return but liquid technology or a high return liquid one, when they are uncertain about the timing of their consumption needs. These special assumptions complicate the analysis considerably, and often mean that the analysis is limited to a model with only a few periods (three in the Diamond-Dybvig case). As a consequence, the literature has not yet converged on the best way to embed financial intermediation into New Keynesian models and other dynamic stochastic models. Two main alternatives have emerged, however, and represent promising avenues for future research.

The first alternative is based on what Freixas and Rochet (2008) call the *industrial organization approach to banking*. In this view, there is a set of agents (banks) that are endowed with the ability to produce an asset (loans) via a pro-

duction function that includes a liability (deposits) as an input, possibly along with other inputs. It is usually assumed that firms or other ultimate borrowers must secure loans to carry out their activities (e.g. firms may need loans to finance working capital). In turn, some other agents (often households) must hold part of their wealth as deposits.

This approach has several advantages, and also some shortcomings. It is intuitive and tractable, and it can be easily extended to accommodate cases of interest (Chari, Christiano and Eichenbaum 1995 is an early example). In addition, one can use it immediately to introduce the idea of "financial shocks" or even "crises", by just assuming that the financial intermediation production function is subject to exogenous random fluctuations. On the other hand, the approach is clearly *ad hoc*. Financial intermediation is modeled as a black box that takes something that we called "deposits" as inputs and spits out something that we call "loans" as output. It could be argued that for several purposes, including monetary policy analysis, it may not be necessary to understand the details of the black box (this is the position of Woodford 2012, for example, to which we return below). But it is likely that those details may matter to fully understand, for example, the impact of financial regulation and its interaction with monetary policy or, more importantly, whether and how financial shocks may be endogenous and related to the rest of the economy.

A recent sequence of papers by Christiano, Motto and Rostagno (henceforth CMR) is a prominent example of this approach. The papers combine banks, modeled after the industrial organization tradition, with financial frictions of the BGG type to arrive at empirically realistic models for estimation and policy evaluation, in the spirit of Smets and Wouters (2007) and Christiano, Eichenbaum, and Evans (2005). CMR have used their models, in particular, that an interest rate rule that responds to credit growth, in addition to inflation and the output gap, may have an edge over the conventional Taylor rule.

Curdía and Woodford (2009) also relies on the industrial organization to banks, although it differs from other models in making assumptions that almost preserve the fiction of a representative household. In their model, households are able to access a set of complete financial markets but only occasionally; in periods without such access, households can borrow from or hold deposits at a bank. In turn, the bank produces loans and issues deposits subject to a production technology, as characteristic of the industrial organization approach. Finally, the discount factor of each household is stochastic, fluctuating between high and low values.

Curdía and Woodford show that each household must save, holding deposits

in the bank, when its discount factor is low, and a borrow from the bank when its discount factor is high. In such a context, Curdía and Woodford identify one key implication of financial frictions for inefficiency, namely that the marginal utilities of consumption of savers and borrowers can be different. The wedge between them can be time varying and is reflected in the spread between the interest rates for loans and deposits.

Equilibrium in the Curdía-Woodford model turns out to be relatively tractable; in fact, a first order approximation can be described by a few equations that resemble the New Keynesian system (1)-(3) quite closely, augmented by random terms that capture the (possibly time varying) marginal utility wedge. In particular, the IS equation has the form

$$y_t + \chi\Omega_t = E_t\left[y_{t+1} + \chi\Omega_{t+1}\right] - \sigma\left[i_t - E_t\pi_{t+1}\right] \tag{5}$$

where Ω_t is a measure of the marginal utility wedge, and the Phillips Curve has the form:

$$\pi_t = \kappa_y y_t + \kappa_\Omega \Omega_t + \beta E_t \pi_{t+1} + u_t \tag{6}$$

Finally, the loss function L_t in (2) has to be augmented with the marginal utility wedge:

$$L_t = \pi_t^2 + \varphi_y y_t^2 + \varphi_\Omega \Omega_t^2 \tag{7}$$

Then Curdía and Woodford argue that it may be desirable for monetary policy to respond to Ω_t or, which is about the same in the model, to variations in interest spreads, a prescription that echoes a recent proposal of Taylor (2008) and Mc Culley and Toluoi (2008). Alternatively, policy should react to the growth of credit, as proposed by CMR. In both cases, however, it is essential that monetary policy be able to affect the stochastic properties of the marginal utility wedge. This requires that marginal financial intermediation costs depend on the volume of credit. Hence the properties of the black box financial technology, which are assumed and not derived from first principles, turn out to be crucial for the policy implications.

An alternative approach to banking in dynamic equilibrium models has been developed recently by Gertler and Karadi (2011) and expanded in Gertler and Kiyotaki (2010). The main idea is to assume that there is a set of "bankers" that, in contrast with the rest of the population, have a comparative advantage in the lending business because they are endowed with the ability to screen profitable investment projects (Gertler and Karadi 2011 make the extreme assumption that entrepreneurs can borrow only from banks) . But bankers are assumed to be able

to pledge to outsiders only a fraction of the returns on their loans. As emphasized by Kiyotaki and Moore (1998), in order to attract outside financing bankers must then commit their own net worth into the lending business. In equilibrium, the amount of bank credit is a multiple of the bankers' capital. As in BGG, the evolution of net worth becomes a crucial state variable that affects aggregate dynamics. But the relevant variable of Gertler-Karadi-Kiyotaki is not the net worth of firms but the net worth of banks.

Like the industrial organization approach, the model of Gertler-Karadi-Kiyotaki is quite tractable and intuitive. One of its distinctive advantages is that it allows one to characterize the dynamics of bank leverage, which is important in enhancing the amplification and persistence of exogenous shocks. And different kinds of exogenous financial shocks are introduced easily. Gertler and Karadi (2011), for example, investigate the impact of an exogenous fall in the amount of bank capital, interpreted as a "financial crisis".

Of course, one can also criticize the Gertler-Karadi-Kiyotaki model on a number of grounds. In particular, one could argue that the asset-liability structure of banks in this model does not display the maturity mismatches that are a hallmark of real-world banks. Whether or not this is a crucial flaw is yet to be elucidated. In the meantime, the Gertler-Karadi-Kiyotaki model represents a very promising avenue for current and future research efforts.

4.2. Unconventional Central Bank Policies in Advanced Countries

In response to the global crisis, central banks in advanced economies have resorted to a wide array of policy tools other than the policy interest rate. This was necessary in part because of the need of additional monetary stimulus as the policy rate reached its zero limit, as already noted. But unconventional policies have been also motivated by the need to address severe disruptions in financial markets and financial intermediation (see IMF 2013 for a good discussion and summary).

While unconventional policies have been generally credited with preventing advanced economies from falling into another Great Recession and with saving the banking system, there is much debate about them. The literature has been mostly empirical, and it is fair to say that a lot of uncertainty remains about the impact of unconventional policies on different variables and in different situations.

Perhaps more importantly from the viewpoint of our discussion, our understanding of unconventional policies and, especially, of their role in the overall

monetary framework is hampered by the current lack of a commonly accepted analytical model. As we have argued, the basic New Keynesian paradigm assumes perfect financial markets, which often leads to the irrelevance of unconventional policies of interest (see, for example, Eggertsson and Woodford 2003 for a proof in the case of QE). In addition, many policies of interest, such as indirect credit easing, are channeled via banks and other financial intermediaries, and hence can presumably only be understood in models that feature such intermediaries.

Some progress has been made, however. Prominently, Gertler and Karadi (2011) used their dynamic equilibrium model with banking to ask whether government intervention in credit markets (version of credit easing) was desirable in response to a "crisis" (modeled as an unanticipated and exogenous loss of bank capital). Gertler and Karadi argue that it is, but their analysis raises as many issues as it answers. For example, while it is assumed that private bankers are subject to agency costs when serving as financial intermediaries, the government is not. Then the question emerges of whether it would be desirable for the government to take over all of the financial intermediation business. To prevent that conclusion, Gertler and Karadi assume that the government intermediation is subject to exogenous deadweight losses. This is clearly ad hoc. In addition, even in the presence of such losses, one can conjecture that the government should be in the intermediation business all of the time. But this conclusion may be unattractive, at least intuitively.

In short, the literature is still at an early stage, and a dominant paradigm in terms of a dynamic model useful for monetary policy evaluation, featuring realistic and convincing financial frictions and financial intermediation, is yet to emerge. But there is a lot of current research on this front, so one can hope for a suitable paradigm to be developed in the near future.

4.3. Unconventional Policies in Open Economies

Relative to the case of advanced, large economies, the issue of unconventional policies in small open economies, especially emerging ones, presents a number of interesting complications. The first one is that, in addition to domestic currency, a foreign currency (such as the U.S. dollar or the Euro) and the associated relative price, the exchange rate, play a major role in shaping the economy's developments. Of course, traditional macroeconomic models have often acknowledged this fact by assuming, for example, that the exchange rate may affect the relative price of tradables and nontradables, and hence the current account. But recent research

has emphasized financial implications of the fact that domestic residents may have large debts in foreign currency (liability dollarization) or the fact that international borrowing may be constrained by the availability of collateral in terms of foreign currency.

An associated complication is that the domestic central bank can only print domestic currency but not foreign currency. This restricts the ability of the central bank to engage in some unconventional policies, such as providing liquidity in foreign currency (which can be seen as a form of credit easing).

Further, prior to the onset of the global crisis, many central banks in open economies had already departed from the textbook IT recipe in terms of exchange rate intervention and management and foreign reserves accumulation. Large stocks of reserves turned out to be very useful during the crisis, especially after the Lehman bankruptcy, as many central banks could resort to credit easing in foreign currency.

These considerations suggest that a satisfactory understanding of central bank policy, both conventional and unconventional, in open economies requires the development of models that: (a) feature dollarization, that is, a role for a foreign currency, especially in describing financial contracts and capital flows; (b) feature financial frictions that interact in an essential way with dollarization, and (c) shed light on the impact of foreign exchange operations and central bank operations not only in domestic currency but also in foreign currency, taking into account the fact that the central bank has access only to a limited amount of foreign exchange (at least in the short run). Such models would then be helpful to rationalize the observations above as well as many others. So, in particular, a model of this kind might provide a rationale for fear of floating and the prevalence, at times, of foreign exchange intervention. It would also identify the limits on the central bank's ability to manage exchange rates and how these limits depend on the amount of international liquidity available to the central bank. A fortiori, it would help explain the phenomenon of reserves accumulation.

As in the case of advanced economies, there has been some progress in this direction. For instance, a recent interesting working paper by Medina and Roldos (2013) develops a model that features (a) and (b) above, although not (c). Likewise, Céspedes, Chang and Velasco (2012) features (a), (b), and (c), but not in a dynamic model. Again, there is a lot of current research in this direction, so that the state of the art can change soon.

5. Monetary Strategy, Crises, and Macro Prudential Policy

5.1. Crises, the Lender of Last Resort, and the Monetary Regime

In the worst of the recent crisis, and especially following the Lehman crisis, central banks around the world stepped up programs of liquidity assistance, as already noted, especially to financial intermediaries. These programs were seen as extending the role of central banks as lenders of last resort and were widely agreed to have prevented worse financial panics, as predicted by Diamond and Dybvig (1983) and other leading models of bank runs. In the context of our discussion, however, they raise the question of whether last resort lending can be accommodated in the existing framework of analysis of monetary strategy and, if so, how.

The answer is not obvious, since theoretical models suggest that a central bank commitment to serve as a lender of last resort can place restrictions on feasible monetary strategies. For example, in Chang and Velasco's (2000) model of financial crisis in open economies, the central bank cannot serve effectively as a lender of last resort while fixing the exchange rate. It has also has been suggested that a central bank that attempts to ensure macroeconomic stability, for example by engineering low inflation and low interest rates, may exacerbate financial instability at the same time, perhaps by encouraging excessive risk taking and asset price bubbles.

In order to understand these issues, we would ideally have a dynamic model with a financial sector in the spirit of Diamond and Dybvig (1983). Such a model would describe how financial crises may emerge and how they interact with the rest of the economy. Then one could analyze how different monetary policy options may reduce the incidence of crises and, likewise, how financial regulation policies and other policies dealing with the financial sector may affect the severity of crises and, hence, their associated aggregate effects.

We do not have such a model yet, although recent efforts by Gertler and Kiyotaki (2013) and others are heading in that direction. Woodford (2012) has suggested, however, that the development of a framework integrating a theory of financial crises into the dynamic models typical of monetary analysis may not be as urgent. Instead, Woodford shows, one can go a long way towards characterizing optimal monetary policy if one includes the financial sector as a source of random shocks whose probability distribution depends, in some reduced form way, on some "obvious" endogenous variables, such as credit growth or leverage. This would lead, in Woodford's framework, to the suggestion that monetary policy should

be as usual much of the time, but tilt towards less stimulus as credit or leverage grow, increasing the probability of a "crisis".

In the context of the Curdía-Woodford (2009) model, the key assumption of Woodford (2012) is that the marginal utility wedge Ω_t in (5) and (6) be stochastic, taking a low "normal " value Ω_L and a high "crisis " value Ω_H. The probability of crisis is then viewed as the probability of switching from Ω_L to Ω_H, denoted by γ_t, which is postulated to be an increasing and convex function of the amount of leverage V_t in the financial sector:

$$\gamma_t = \gamma(V_t) \tag{8}$$

Leverage growth is then assumed to depend on real activity:

$$V_t = \rho_V V_{t-1} + \xi y_t \tag{9}$$

Finally, the social loss function is assumed to be a version of (7). It then not difficult to see that monetary policy should react to leverage in normal times (i.e. when Ω_t is still Ω_L) and become more restrictive as leverage grows, to reduce the probability of a "crisis".

From a practical viewpoint, Woodford's suggestion may be a sensible way to move forward. But one may contend that only a true model of crises would convincingly identify the "obvious variables" that affect the probability of crisis, and suggest how those variables affect that probability. In terms of the structure above, one may quarrel with the specification of the function γ in (8), for example, and ask whether other variables should be included as arguments. Likewise, one may question whether (9) is warranted. In addition, Woodford's modeling strategy provides no information on how regulation and other policies directed at the financial sector affect the aggregate economy and, hence, how such policies interact with monetary policy.

5.2. Macro Prudential Policy and Regulation

The previous remarks should also help placing the issue of macro prudential policy and regulation into the overall monetary policy framework. Macro prudential policy measures, such as capital requirements, taxes on borrowing by financial intermediaries, or restrictions on maturity mismatches and leverage, can be seen as an attempt to affect the incidence of financial shocks or, if one adopts Woodford's (2012) perspective, to change the mapping between endogenous aggregate variables and the probability of crises. In terms of the equations of the preceding

subsection, macroprudential policies might change the function γ or the relation 9 between leverage and output.

A satisfactory understanding of macro prudential policy requires, therefore, investigating what lies behind the aforementioned mappings. There are some current research efforts in that direction, notably Benigno, Chen, Otrok, Rebucci, and Young (2012), Angeloni and Faia (2009), and Angeloni, Faia and Lo Duca (2013), but the literature is still young and much remains to be done.

6. Final Remarks

Because of space and focus, we have not expanded on several related issues that have received attention in the debate and may be fundamental. One is the question of the tasks assigned to the monetary authority as opposed to other government instances. It may be argued that objectives other than the traditional ones of inflation and perhaps full employment, particularly financial stability, should be handled by fiscal authorities or some other entities separate from the central bank. This would allow IT to be preserved without much change. However, such a separation may be unfeasible in practice. Also, there may be good reasons for the central bank to be charged with some of the tasks in question. For example, a central bank that can provide liquidity at will is the natural lender of last resort. To see contrasting views, see Svensson (2011) and Blinder (2010).

Another important issue if that our understanding of monetary policy remains constrained by our very limited understanding of liquidity. What exactly is it? How is liquidity created? Who can supply it? For recent discussions, see Tirole (2011) and Calvo (2013).

To close, one may note that the fact that we have been discussing how inflation targeting will evolve and change as a result of the global crisis, as opposed to its dismissal as the leading framework for monetary policy, is a testament for its resilience and appeal. Historically, other frameworks collapsed and were abandoned after comparable crises: the Gold Standard after the Great Depression, or fixed exchange rates after the emerging markets crises of the 1990s.[1] That inflation targeting has survived thus far suggests that it is here to stay, albeit changed in some of the directions outlined here.

[1] I owe this observation to Luis Catao.

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