Heterodox Central Banking

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In response to the current global crisis, the U.S. Federal Reserve and other central banks around the world have implemented diverse policy measures, including purchasing a wide range of securities, lending to financial institutions, intervening in foreign exchange markets, and paying interest on reserves. Some central banks have also reduced monetary policy interest rates to minimum levels (reaching a lower bound) and have announced an explicit commitment to keep interest rates there for a prolonged period. This set of instruments contrasts with a conventional view—embedded in the predominant monetary policy models—in which a central bank controls only a short-term interest rate, such as the Federal Funds rate.

Some of the previous actions may be classified as responses to increasing demand for liquidity in a context of enormous financial uncertainty. Examples of this liquidity provisioning by central banks are the repurchase operations initiated in many economies to provide U.S. dollar liquidity during the period surrounding the bankruptcy of Lehman Brothers. Other actions may be sorted into those attempting to deal with malfunctioning financial markets (insufficient lending to non-financial firms or high lending spreads) and those attempting to enhance the monetary policy stimulus under the lower-bound constraint.

This paper discusses the theoretical and practical aspects of these heterodox policies. In terms of theory, the paper focuses on

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the two alternative arguments that have been offered to rationalize such policies: the desirability of further monetary stimulus when interest rates are already at zero, and the need to unlock financially intermediated credit when it freezes in a crisis. On the first argument, we provide a framework to analyze the theoretical mechanisms through which quantitative easing may be effective to deal with the lower bound constraint. We then show that the effectiveness of such unconventional policies depends crucially on the central bank's ability to commit to future policy, in line with Krugman (1998). Regarding the second argument, we present a model that helps us to introduce a role for unconventional monetary policy, in the context of non-trivial financial intermediation. We then argue that the introduction of financial intermediaries in standard models produces results that challenge conventional wisdom about the effects of non-conventional policies.

In terms of recent practice, we provide evidence arising from the recent experience of central banks that have implemented inflation targets as part of conducting monetary policy. We associate the different monetary policy actions with different phases of the recent financial crisis and with different objectives. In our analysis we focus on evaluating efforts to increase monetary policy stimulus and deal with disrupted financial markets.

The rest of the paper is organized as follows. Section 1 presents a theoretical discussion of two relevant issues that have been at center stage in both policy and academic discussions about unconventional policies during the current crisis: the role of credibility and the importance of financial frictions and bank capital. Section 2 provides a more empirically oriented account of recent events. We first discuss the timing and the type of unconventional policies that have been implemented. We then compare several alternative measures that can be used to assess the monetary policy approach, particularly when the policy rate has reached its lower bound. Finally, we provide descriptive evidence on the effects of these policies on the shape of the yield curve and the lending-deposit spreads. Section 3 concludes.

1. Rationalizing Heterodox Monetary Policy

1.1 Monetary Policy at the Edge: The Role of Credibility

One often mentioned justification for unconventional monetary policy is that the usual monetary instrument—the control of an overnight interest rate in the interbank market—may have reached a limit. In particular, this is the case when a monetary stimulus is deemed to be desirable but the policy rate is a nominal one that cannot be pushed below zero (or a value slightly greater than zero). If the policy rate is already at or close to the lower bound, the central bank must look for alternatives to provide monetary stimulus.

Clearly, the current crisis has brought several countries to a situation in which policy interest rates are close to zero, but expansionary policy appears warranted. Much less clear, however, is whether that fact is sufficient to justify the kind of unconventional policies that we have observed in practice. Can one appeal to the zero-lower-bound problem to rationalize, for example, the striking expansion in the size of the Federal Reserve's balance sheet and the changes in its composition? We argue that the answer can be either affirmative or negative, depending on the policy environment and, above all, on the central bank's ability to commit to future policy.

The starting point of our argument is the observation that currently accepted macroeconomic theory implies that the zero bound on interest rates will rarely, if ever, be a truly binding constraint for a central bank that can perfectly commit to future policy. Recent theories emphasize that a central bank can affect economic decisions not only through the current setting of its policy instrument—for instance, today's interest rate—but also, and perhaps much more effectively, through its impact on the public's expectations regarding the future settings of the instrument. The corollary is that the central bank can always provide some stimulus to the economy, even if the policy rate is at the zero bound, by committing to reducing future policy rates below levels previously expected (which is feasible if the policy rate was expected to be positive at some point in the future).

Thus, for example, Bernanke and Reinhart (2004, p. 85) argue that one of the strategies available for stimulating the economy that does not involve changing the current value of the policy rate is "providing assurance to investors that short rates will be kept lower in the future than they currently expect." The same argument has been embraced recently by the European Central Bank (Bini Smaghi, 2009), the Bank of Canada (Murray, 2009), and others. In fact, even Krugman's (1998) pioneering discussion of Japan implied that the Bank of Japan could have escaped the liquidity trap by promising to keep interest rates sufficiently low for some period, even after inflation had become positive (see also Svensson, 2003).

In short, the zero lower bound on interest rates is unlikely to be a serious constraint on a central bank that can pre-commit to policy. One could conjecture, however, that unconventional policies such as "quantitative easing" or "credit easing" may still be useful to complement conventional policy. It is somewhat surprising, however, to realize that that conjecture is quite unlikely to hold.

This key point has been developed most convincingly by Eggertsson and Woodford (2003). They show that, once a strategy for setting current and future policy rates is in place (for example, using a Taylor-type rule), real allocations and asset prices become independent of whatever the central bank does with the composition or size of its balance sheet during periods in which the policy rate is zero.

It may be worth expanding on the intuition behind this important result, if only to stress its generality. Eggertsson and Woodford's model is a variant of the canonical New Keynesian sticky price model developed by Woodford (2003) and others. In that model, and many others, all asset prices are determined once the equilibrium pricing kernel—or, the stochastic discount factor—is given. Likewise, the stochastic discount factor determines the relevant budget constraint for the household and producer's pricing decisions.

In this context, an interest rate rule can affect aggregate outcomes by establishing a relation between the stochastic discount factor and other variables, such as inflation or the output gap. In equilibrium, an equation as follows expresses the relationship:

$$\begin{aligned}\left(E_t \beta \frac{\lambda_{t+1}}{\lambda_t} \frac{P_t}{P_{t+1}}\right)^{-1} &= 1 + i_t \\ &= \phi(\mathbf{Z}_t),\end{aligned}$$

where β is the average household's discount factor, λ_t is the marginal utility of consumption, P_t the price of consumption, i_t the nominal interest rate for loans between periods t and $t+1$, and ϕ is a function of a vector of variables $\mathbf{Z}_t$, typically inflation and output. The first equality reflects the household's optimal portfolio decisions; here, the stochastic discount factor is given by the random variable $\beta\lambda_{t+1}/\lambda_t$. The second equality says that the central bank sets the interest rate i_t as a function ϕ of the vector of variables $\mathbf{Z}_t$. In equilibrium, then, interest rate policy (for example, a choice of the function ϕ and the vector $\mathbf{Z}_t$) implies a relation between the stochastic discount factor, inflation, and the vector $\mathbf{Z}_t$. Indeed, this is the main (and often the only) way in which interest rate policy affects aggregate outcomes.

If the zero bound on the policy rate i_t were not a binding constraint, a choice of an interest rate rule $\phi(\mathbf{Z}_t)$ would leave no room for "quantitative easing", that is, independent control of the monetary base. Demand would determine the quantity of money, with the central bank adjusting the base as necessary to clear the market (this indeed is what an interest rate rule would mean). In addition, under usual assumptions about fiscal policy, changes in the composition of the central bank's balance sheet—and, more generally, in the consolidated version of the government's balance sheet—are irrelevant for aggregate outcomes. This is because the latter can be shown to depend only on the present value budget constraint of the government, which is given by its initial debt plus the appropriately discounted value of (possibly state-contingent) fiscal deficits.

Eggertsson and Woodford (2003) extend this logic to situations in which the interest rate policy $\phi(\mathbf{Z}_t)$ may prescribe an interest rate of zero under some circumstances—that is, for some values of the vector $\mathbf{Z}_t$. In those cases, they assume that the demand for money is indeterminate (the real demand for money being only bounded below by some satiation level). This allows the central bank to determine the quantity of money independently, in other words, to engage in quantitative easing. They show, however, that aggregate allocations are independent of the details of such quantitative easing. The logic is simple: as we just discussed, quantitative easing could affect aggregate outcomes if it had an impact on the stochastic discount factor, but the latter is pinned down by the function ϕ, as in the absence of the lower-bound problem.

The justification for the last assertion is illuminating. The assertion would be immediate if the marginal utility of consumption λ_t were independent of real money balances. Eggertsson and Woodford assume, however, that utility may depend on real balances in a nonseparable way, so λ_t may depend on M_t/P_t. However, if the interest rate is driven to zero, real balances must exceed the satiation level, which in turn means that the quantity of money no longer has any effect on utility and—all the more certainly—on λ_t.[1] Having established that quantitative easing is irrelevant at zero interest rates, the irrelevance of altering the composition of the central bank's balance sheet follows, as before.

1. It is in this exact sense that money and bonds become perfect substitutes at zero interest rates.

Our discussion stresses that the logic behind the Eggertsson-Woodford irrelevance result is quite general and, hence, extends to a very broad class of models, including those most current. The result, in particular, does not hinge on the absence of imperfectly substitutable assets, which may have led some to suspect that changes in the size and composition of the central bank balance sheets would have portfolio balance effects. Indeed, the absence of portfolio balance effects could be considered a significant flaw, and one could conjecture that models featuring such effects may overturn the irrelevance argument. However, a compelling portfolio balance model of the effects of policies involving the central bank balance sheet has yet to be developed. In addition, the empirical evidence about portfolio balance effects provides little support for them, as stressed by Bernanke and Reinhart (2004, p. 87): "the limited empirical evidence suggests that, within broad classes, assets are close substitutes, so that changes in relative supplies of the scale observed in U.S. experience are unlikely to have a major impact on risk premiums or even term premiums (Reinhart and Sack, 2000)."

To summarize, we have argued that a central bank that can commit in advance to a conventional interest rate policy will generally find that the zero bound on interest rates is not a binding restriction and, in particular, can provide monetary stimulus, even in a liquidity trap, by promising that future policy rate levels will be lower than they would have been otherwise. In addition, such a central bank will find that quantitative easing, portfolio management maneuvers, and other strategies for altering the size and composition of its balance sheet at times of zero interest rates are irrelevant.

Given the above, why is it that central banks have often been unable to come out of deflationary liquidity traps by simply promising expansionary policy in the future? The key conjecture is that such promises may not be credible. Credibility is a crucial constraint in this situation, as several authors have emphasized, starting with Krugman's (1998) analysis of the Japanese recession.

One implication of this observation is that the literature is full of warnings and admonitions about the need for central banks to ensure that announcements of future policy are believable, suggesting that central banks can even "manage expectations" independently of interest rate policy. For example, the *Banque de France* recently stated that one unconventional policy is "influencing the yield curve by guiding expectations" (*Banque de France*, 2009, p. 5). There is little guidance in these statements, however, as to how, precisely, the central bank can independently manage expectations. Bernanke and Reinhart (2004, p. 86) acknowledge this fact, stating that "the central bank's best strategy for building credibility is to build trust by ensuring that its deeds match its words...the shaping of expectations is not an independent policy instrument in the long run."

Others have responded to the credibility issue by emphasizing the need for improving transparency and clear communication of central bank policy intentions. Of course, it is hard to argue with the view that transparency and clear communication are desirable aspects of central bank policy. Aside from the fact that it is not clear why the need for them is greater when interest rates are close to zero than at other times, however, there is no generally accepted theory of how more or less transparency affects monetary transmission channels.

A related claim, of particular relevance to our discussion, is that changes in the size and composition of the central bank balance sheet can help the credibility of the central bank's announcements about future policy. In fact, some authors have claimed that this is the main role of unconventional policies. For example, Bernanke and Reinhart (2004, p. 88) argue that a central bank policy of setting a high target for bank reserves "is more visible, and hence may be more credible, than a purely verbal promise about future short-term interest rates." Likewise, Eggertsson and Woodford (2003) conjecture that "shifts in the portfolio of the central bank could be of some value in making credible to the private sector the central bank's own commitment to a particular kind of future policy... 'Signaling' effects of this kind... might well provide a justification for open market policy when the zero bound binds."

To date, attempts to make these claims more precise have been lacking, but a longstanding theory of monetary policy under imperfect credibility suggests several ways to develop this view. To illustrate, let us examine the implications of a simple model of monetary policy.

1.1.1 Unconventional policy: An illustrative model

We shall extend the model of Jeanne and Svensson (2007, henceforth *JS*). Consider a small open economy with a representative agent that maximizes the discounted expected utility of money holdings and consumption of tradables and non-tradables. The period utility of tradables is log C_t, where C_t is a Cobb-Douglas aggregate of home (h) non-tradables and foreign (f) tradables,

$$C_t = C_{ht}^{1-\alpha} C_{ft}^{\alpha}.$$

C_{ht} is, in turn, a conventional Dixit-Stiglitz aggregate of domestic varieties. With the world price of foreign tradables normalized to one, the price of consumption is therefore

$$P_t = P_{ht}^{1-\alpha} S_t^{\alpha},$$

where P_{ht} is the price of home non-tradables and S_t the nominal exchange rate.

The representative agent chooses consumption and holdings of money, a world noncontingent bond, and domestic bonds. His sources of income in each period are wages, profits of domestic firms, income from previous investments, and a transfer from the central bank (denoted Z, as in *JS*). It turns out that these transfers are not needed for our argument, but let us keep them in for now to preserve the *JS* notation.

There is a central bank that can print domestic currency freely to finance transfers and a portfolio of securities. A bond of maturity k is a promise to pay one unit of consumption at time $t + k$. For simplicity, assume that k can be either one or two, such that there are "short" (one-period) bonds and "long" (two-period) bonds.[2]

Let Q_t^s denote the home currency price at t of a bond promising one unit of consumption at $t + s$, where $s = 1,2$. Letting B_t^s be the central bank holdings at the end of period t of the corresponding bond, the central bank's budget constraint is

$$Z_t + Q_t^1 B_t^1 + Q_t^2 B_t^2 = M_t - M_{t-1} + B_{t-1}^1 + Q_t^1 B_{t-1}^2.$$

In contrast with *JS*, who examine the role of foreign exchange intervention, we assume that the central bank keeps zero foreign exchange reserves. Instead, it holds a portfolio of short and long bonds. This means that, in the central bank's budget constraint, the crucial term will be the last one on the right-hand side, which

2. Notice that we assume that bonds are real promises. This is a nontrivial assumption, discussed at length in the working paper version of *JS*.

denotes the current value of long bonds purchased the previous period. Hence, changes in the price of long bonds can be a source of gains or losses for the central bank.

Jeanne and Svensson (2007) prove two results. The first is that a central bank that minimizes a conventional expected discounted value for losses that depends only on inflation and the output gap may be unable to implement an optimal policy to escape from a liquidity trap, if it cannot commit to honoring promises of future policy. The second result is that this commitment problem may be solved if the central bank cares enough about its capital position. The mechanism described by *JS* is for the central bank to initially acquire enough foreign exchange reserves, by either printing domestic currency or reducing transfers to the Treasury. This results in a currency mismatch and implies that, were the central bank to subsequently deviate from a promise of high inflation, the concomitant currency appreciation would result in a capital loss via the fall in the value of the central bank's foreign reserves. This would deter the central bank from reneging on a promise of high inflation, if we can assume that the central bank cares about its capital.

Here, we will describe a similar argument that relies on the management of asset maturities in the central bank's portfolio. While the logic of the mechanism is essentially the same as in *JS,* we will see that there are some interesting differences. First, note that the capital of the central bank is, by definition, the value of its assets minus liabilities:

$$V_t + Q_t^1 B_t^1 + Q_t^2 B_t^2 - M_t,$$

which, using the budget constraint above, can be rewritten as:

$$V_t = -M_{t-1} + B_{t-1}^1 + Q_t^1 B_{t-1}^2 - Z_t.$$

This expresses, in particular, that the capital position of the central bank improves if the price of short bonds, Q^1_t, increases *and* the central bank had a long position in two period bonds at the end of the previous period. This will prove to be crucial.

Before elaborating on this point, let us discuss competitive equilibria. *JS* make the usual assumptions of setting the current account to zero in all periods and making tradable consumption constant. Non-tradable consumption, meanwhile, equals non-tradable output:

$$C_{ht} = Y_t.$$

Non-tradables are produced with only labor and a linear technology, by monopolistically competitive firms that choose prices one period in advance. As is well known, the typical firm (z) chooses a price that is a constant markup over marginal cost:

$$P_{ht}(z) = \frac{\varepsilon}{\varepsilon - 1} E_{t-1} \frac{W_t}{A_t},$$

where ε is the elasticity of substitution between varieties, W_t the wage, and A_t aggregate productivity. Now, optimal labor choice implies that

$$\frac{W_t}{P_{ht}} = \frac{C_{ht}}{1-\alpha} = \frac{Y_t}{1-\alpha},$$

from which firm z's relative price is

$$\frac{P_{ht}(z)}{P_{ht}} = E_{t-1} \frac{Y_t}{Y_t^*},$$

where

$$Y_t^* = \frac{\varepsilon}{\varepsilon - 1}(1-\alpha)A_t$$

is the rate of natural output.

In equilibrium, $P_{ht}(z)/P_{ht}$=1, because all firms are identical, and we arrive at the aggregate supply equation:

$$1 = E_{t-1} \frac{Y_t}{Y_t^*}.$$

Here, the real exchange rate is defined as

$$Q_t = \frac{S_t}{P_{ht}},$$

which, in equilibrium, is given by

$$Q_t = \frac{\alpha / C_{ft}}{(1-\alpha)/C_{ht}} = \frac{\alpha}{(1-\alpha)} \frac{Y_t}{\bar{C}_f},$$

where $\bar{C}_f$ is the constant equilibrium consumption of tradables. Therefore, the real exchange rate depreciates if domestic output increases, which is one source of *JS*'s main results.

To allow for the possibility of a "liquidity trap," assume that there is a nominal bond, and that the nominal interest rate must equal

$$e^{-i_t} = \delta E_t \frac{P_{ht}}{P_{h,t+1}} \frac{Y_t}{Y_{t+1}}$$

from the household's Euler condition, where δ is the discount factor. The real interest rate must then satisfy

$$e^{-r_t} = \delta E_t \left(\frac{Y_t}{Y_{t+1}} \right)^{1-\alpha}.$$

This is a key equation, which states that the real interest rate must fall if output is expected to decline. *JS* consider a situation in which at $t = 1$ the log of productivity is equal to its previous steady state, say a, but we know that it will fall to $b < a$ from period $t = 2$ on. This can lead the economy to a liquidity trap, as we now argue.

Start by assuming that the central bank minimizes a conventional loss function $E \sum \delta^t L_t$, where

$$L_t = \frac{1}{2}[(\pi_t - \pi)^2 + \lambda(y_t - \bar{y}_t)^2],$$

where π is the inflation target and $\bar{y}_t$ is the natural level of output. From hereon, lowercase variables are logarithms of their uppercase counterparts. To see how a liquidity trap may emerge, note that

$$\pi_t = p_t - p_{t-1} = p_{ht} + \alpha q_t - p_{t-1}.$$

Letting the natural real exchange rate be defined in the obvious way,

$$\bar{Q}_t = \frac{\alpha}{(1-\alpha)}\frac{\bar{Y}_t}{\bar{C}_f},$$

we obtain

$$\pi_t = p_{ht} + \alpha\bar{q}_t - p_{t-1} + \alpha(y_t - \bar{y}_t).$$

Under discretion, the policymaker would minimize L_t subject to the preceding equation, which would yield

$$\pi_t = \pi - \frac{\lambda}{\alpha}(y_t - \bar{y}_t).$$

Recalling, however, that there are no unexpected shocks in periods $t = 2$ on, in equilibrium $Y_t = \bar{Y}_t$ for all t except possibly for $t = 1$. Therefore, $\pi_t = \pi$ for $t = 2,3,...$ such that inflation is at the target in all periods, expect possibly in period $t = 1$.

Jeanne and Svensson (2007) show that, if b is sufficiently low relative to a, the economy will fall into a liquidity trap in period one—that is, a situation in which the interest rate i_1 falls to zero, and output falls short of the natural level. This results in lower welfare than under commitment. With commitment, the central bank would promise to increase π_2 over π to spread the cost of the productivity fall between periods 1 and 2. However, in the absence of a commitment device, this promise would not be kept: in period 2, it would be optimal for the central bank to reduce π_2 to the target π.

To see the role of debt management, let us focus on the pricing of bonds of different maturities. Recall that there is no more uncertainty after period one. Hence, by arbitrage,

$$\frac{P_{t+1}}{Q_t^1} = e^{i_t}.$$

This says that the return on one-period bonds must be equal to the return on nominal bonds. Now, recalling that $\pi_t = \pi$ for $t \geq 2$,

$$\frac{P_{t+1}}{Q_t^1} = \frac{P_{t+1}}{P_t}\frac{P_t}{Q_t^1} = e^{i_t} = e^{r^*+\pi},$$

where r^* is the natural real rate of interest,

$$Q_t^1 = e^{-r^*} P_t. \tag{1}$$

Note that this says that the price of one-period bonds is proportional to the price level from period 2 on.

Also, under perfect foresight, arbitrage implies that the price of a two-period bond equals the product of the prices of one-period bonds now and next period:

$$Q_t^2 = Q_t^1 Q_{t+1}^1. \tag{2}$$

These facts now lead us to our main result. Suppose that, at $t = 1$, the central bank learns about a future decline in productivity and sells x short bonds and buys an equivalent amount of long bonds. The amount of long bonds purchased is denoted by $Q_1^1 x + Q_1^2 B_1^2 = 0$, that is

$$B_1^2 = -\frac{Q_1^1}{Q_1^2}x.$$

By construction, this operation has no impact on either the budget constraint or the central bank's capital position at $t = 1$.

If the central bank could commit to the optimal policy (under commitment), the operation would not affect its budget constraint nor its capital position in any subsequent periods either. This is because the arbitrage condition (2) would guarantee that the value of the inherited portfolio would be zero:

$$B_1^1 + Q_2^1 B_1^2 = x + Q_2^1\left(-\frac{Q_1^1}{Q_1^2}x\right) = 0.$$

Notably, this is an instance of Eggertsson and Woodford's irrelevance result: under commitment, open market operations are irrelevant.

But suppose that the central bank has no commitment and can contemplate a deviation from the optimal plan. As shown in *JS* (and intuitively obvious), the central bank would then have an incentive to reduce inflation towards the target, thus cutting P_2 from its optimal level to a lower level, say P_2'. However, since there are no incentives for further deviations, prices of bonds maturing at $t = 3$ would fall, by equation (1), to some level $(Q_2^1)'$. Then the value of the central bank portfolio would be:

$$\begin{aligned} B_1^1 + (Q_2^1)' B_1^2 &= x[1 + (Q_2^1)'(-\frac{Q_1^1}{Q_1^2})] \\ &= x\left[1 - \frac{(Q_2^1)'}{Q_1^2}\right]. \end{aligned}$$

This is less than zero if x is negative and $(Q_2^1)' < Q_2^1$, that is, if the central bank surprisingly changes policy in a way that leads to lower prices. It follows that the deviation is not profitable for the central bank if it cares about its capital position and x is negative and sufficiently large in absolute value.

In other words, the central bank can ensure the credibility of an inflationary policy by changing the composition of its balance sheet, selling short-term bonds and holding long-term bonds. This is crucial to equilibrium, not because such an unconventional measure would change the equilibrium outcome—which is the same as the outcome under commitment—but because the debt structure can change the incentives for the central bank, discouraging deviation from the desired equilibrium: a deflationary surprise would reduce the value of long-term bonds, inflicting a punishment on the central bank.

The argument here is therefore related to the classic Lucas and Stokey (1983) study of optimal policy under time inconsistency. As in that paper, debt maturity is irrelevant under commitment, but can be crucial under discretion.

Our discussion also stresses that the composition of the central bank's balance sheet can be managed in several alternative ways to provide the proper incentives for the central bank. As mentioned, our argument here is similar but not the same as in *JS*, who focused on international reserves management. Compared with their argument, the one presented here is cleaner because we do not need to worry about central bank transfers (denoted Z above), which figure somewhat prominently in *JS*. In fact, we eliminate the transfers completely. On the other hand, we depend on having a rich enough menu of assets, in this case debts with different maturities.

Our analysis provides a concrete setting in which unconventional central bank policy not only helps but is in fact crucial to implementing optimal monetary policy. What is the value of such an exercise? For one thing, it clarifies the sense in which management of the central bank balance sheet can indeed complement conventional interest rate policy, much more effectively than vague statements, such as "the central bank's open market operations should be chosen with a view to signaling the nature of its policy commitments". Indeed, our analysis has not relied on the existence of asymmetric information of any sort, and therefore leaves no room for any kind of signaling.

Moreover, a formal analysis opens the way to interpreting and identifying the validity (or lack thereof) of many claims in the policy literature. To cite but one example, to justify unconventional measures, the Bank of Canada has cited the principle of "prudence", meaning that the Bank should "mitigate financial risks to its balance sheet, which could arise from changes in yields (valuation losses) or from the credit performance of private sector assets (credit losses)," (Bank of Canada, 2009, p. 29). But in the analysis above it is precisely the possibility of such valuation losses that lend credibility to the central bank's promises to keep interest rates low, even as inflation overshoots its target.

Notably, our analysis explains why, for justification's sake, these operations may have to be carried out *by the central bank*, instead of, say, the Treasury. This is relevant, because often the reasons given to justify altering the size and composition of the central bank's balance sheet are really reasons to change fiscal policy rather than central bank policy. Here, the open market operations in play are designed to affect the central bank's incentives, which would not happen if an alternative agency were to carry out such operations.

1.1.2 Alternative solutions to the commitment problem

Our discussion has emphasized that one fruitful way to rationalize unconventional policy may be to see the management of the central bank's portfolio as a commitment device. This perspective also suggests we should look for more general insights in the rich literature on policy under time inconsistency and lack of commitment.

Walsh (1995), for example, emphasized that one way to solve the classical time inconsistency problem in monetary policy is to provide optimal contracts to central bankers, a view that has been associated with the widespread acceptance of inflation targeting in a context of central bank independence.

Arguably, Walsh's view remains quite relevant to solving the credibility problem with zero interest rates too. In the context of the model described in the preceding subsection (and the analysis in *JS*), we mentioned that a critical part of the solution is the assumption that the central bank cares about its capital. But, where does this concern come from? The problem arose because, presumably, the central banker had been assigned (at some point before the start of the analysis) a mandate to minimize a loss function with inflation and the output gap as arguments. A suggestion echoing Walsh's would then be to enlarge that loss function with a term inflicting a penalty on the central banker, if bank capital were to fall below some value.

But if that is in fact the case, one could and should also ask the more general question, posed by Walsh, of what is the optimal contract to the central banker. This would recognize, in particular, that the contract may not entail an inflation target, even if inflation targeting would be optimal under commitment. This issue may, in fact, have gone beyond theory and become quite influential in practice. Specifically, Svensson (2001) has advocated that one way to solve the credibility problem in a liquidity trap may be to switch the objective of the central bank from inflation targeting to price level targeting, and that strategy has actually been embraced by Sweden. Our analysis suggests that this reform may be understood as a way to modify the loss function assigned to the central banker, to provide the correct incentives for implementing the optimal monetary policy.

1.2 Financial Frictions, Bank Capital, and Heterodox Policy

An alternative justification for central banks resorting to new policy instruments has been that the recent crisis involved a combination of skyrocketing interest rate spreads, frozen credit markets, and paralyzed financial institutions. In this context, it was clear that the traditional monetary policy tool—that is, the supply of bank reserves to target an overnight interbank interest rate—seemed to have become completely ineffective. In particular, additional liquidity in the interbank market was hoarded by the banks, apparently in some cases in an effort to reconstitute their severely impaired capital levels. Thus, several central banks stepped into credit markets and started expanding the size and scope of rediscounting operations, swapping questionable assets for safer government debt and, in some cases, lending directly to the private sector.

These developments have stimulated a small but growing literature attempting to understand the interaction of unconventional monetary policies with financial imperfections and the behavior of the banking system. As the discussion suggests, significant progress on this front will require not only analyzing the implications of endowing the monetary authorities with a policy arsenal that includes more than interest rate control, but also introducing a nontrivial banking system into current theory. This will demand, in turn, dropping the crucial assumption of frictionless financial markets that currently pervades dominant models.[3]

Unfortunately, no theory of banks exists yet that is both widely accepted and tractable enough to be embedded into the stochastic dynamic models that characterize modern monetary theory. As a result, recent attempts have been as much about this modeling issue as about the effects of unconventional policy. For example, an influential study by Christiano, Motto, and Rostagno (2007) models banks, following what Freixas and Rochet (2008) call the "industrial organization" approach. In contrast, in Gertler and Karadi (2009), banks are agents that borrow from households and lend to firms, subject to a moral hazard problem. Similarly, Cúrdia and Woodford (2010) modify the basic New Keynesian model by assuming that households differ in their preferences, thus creating a social function for financial intermediation.

One initial conclusion of these studies of relevance to monetary policy is that augmenting a standard Taylor rule to respond mechanically to changes in the spread between lending and deposit rates may not be optimal. How effective this action is, will depend on the type of shock that generates the increase in the spread. Now, in terms of credit policy—that is, direct lending by the central bank to non-financial firms—this policy would be optimal if private financial markets are sufficiently impaired (Cúrdia and Woodford, forthcoming; Gertler and Karadi, 2009).

However, the state of affairs is such that it may be premature to try to draw firm conclusions from these studies, and indeed the papers just cited are still being refined and may change substantially.

3. Needless to say, the analysis in the previous subsection may require significant changes if perfect financial markets are not assumed.

Nevertheless, they represent a shifting perspective that is likely to stay and, hence, is worth discussing in more detail. To do so, we discuss next a related model of ours, designed to illustrate several of the issues involved.

1.2.1 An illustrative model

This model is a stochastic discrete time version of Edwards and Végh (1997), with one crucial modification: bank lending is constrained by bank capital. This change is not only warranted by current events but also implies, as we will see, a substantial departure in terms of model solution and dynamics.

Consider an infinite horizon small open economy. There is only one good in each period, freely traded and with a world price that we assume to be constant (at one) in terms of a world currency.

The economy is populated by a representative household that maximizes

$$E\sum_{t}\beta^{t}\left[\log c_{t}+\log(1-l_{t})\right],$$

where c_t and l_t denote consumption and labor effort, and β is the household's discount factor.

To motivate a demand for bank deposits, we assume that deposits are necessary for transactions. This results in a deposit-in-advance constraint

$$d_t \geq \alpha c_t,$$

where α is a fixed parameter and d_t denotes bank deposits. Deposits pay interest, which can be expressed in real terms as:

$$1+r_t^d=(1+i_t^d)\frac{P_t}{P_{t+1}},$$

where i_t^d is the nominal interest rate paid on deposits, and r_t^d is the corresponding real interest rate.

The household owns domestic firms and banks, and receives transfers from or pays taxes to the government. Hence its flow budget constraint is given by:

$$\Omega_t^f+\Omega_t^b+T_t+w_t l_t+(1+r_{t-1}^d)d_{t-1}=d_t+c_t,$$

where Ω_t^b and Ω_t^f are profits from banks and firms, respectively, T_t denotes government transfers (or taxes, if negative), and w_t is the real wage. For simplicity, we are assuming that the household cannot lend or borrow in the world market. Our arguments extend easily if the household can lend but not borrow in the world market, as we shall see.

Let $\lambda_t\omega_t$ and λ_t be the Lagrange multipliers associated with the deposit-in-advance constraint and the flow budget constraint, respectively. Optimal household behavior is then given by the first-order conditions:

$$\frac{1}{c_t} = \lambda_t(1 + \alpha\omega_t),$$

$$\frac{1}{1 - l_t} = \lambda_t w_t,$$

$$\lambda_t = \beta E_t \lambda_{t+1}(1 + r_t^d) + \lambda_t\omega_t.$$

These have natural interpretations. In particular, the first condition emphasizes that the household equates the marginal utility of consumption to its shadow cost, inclusive of the cost of the deposit-in-advance constraint. Likewise, the third condition emphasizes that the return to deposits must include the benefit from relaxing the deposit-in-advance constraint.

We now turn to production. There is a continuum of identical domestic firms, each able to produce tradables with a linear technology that employs only labor:

$$y_t = A_t l_t,$$

where A_t is an exogenous productivity shock.

The typical firm maximizes the appropriately discounted value of dividends:

$$E\sum_t \beta^t \lambda_t \Omega_t^f,$$

where flow profits are given by:

$$\Omega_t^f = A_t l_t - w_t l_t + h_t - (1 + r_{t-1}^l) h_{t-1}.$$

To motivate a demand for bank loans, we introduce a working capital assumption in which the firm must borrow a fraction γ of the wage bill from banks, such that

$$h_t \geq \gamma w_t l_t,$$

where h_t denotes the amount that the firm must borrow. The real interest rate on loans is denoted r_t^l, with:

$$1 + r_t^l = (1 + i_t^l)\frac{P_t}{P_{t+1}}.$$

In each period the firm chooses l_t and h_t. Letting ϕ_t be the multiplier on the finance constraint, the first-order conditions for the firm's problem are

$$A_t = w_t(1 + \gamma\phi_t),$$
$$1 + \phi_t = E_t\beta\frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^l).$$

Note that the first condition stresses that the cost of labor must include the financial cost associated with the working capital constraint.

Next, turn to the banking sector. As in Edwards and Végh (1997), banks are modeled following an industrial organization approach. This is appealing, because that approach implies that there will be spreads between deposit and lending rates. But, as mentioned, we depart from Edwards and Végh (1997) by assuming that bank lending is constrained by bank capital.

Banks maximize

$$E\sum_t \beta^t \lambda_t \Omega_t^b,$$

where

$$\Omega_t^b = (1 + r_{t-1}^l)z_{t-1} + f_{t-1}\frac{P_{t-1}}{P_t} + d_t + x_t - (1 + r_{t-1})x_{t-1}$$
$$- z_t - f_t - (1 + r_{t-1}^d)d_{t-1} - \xi_t\eta(z_t, d_t),$$

z_t denotes credit to firms, f_t required reserves, x_t foreign borrowing, and r_t the cost of foreign borrowing. We also assume a reserve requirement

$$f_t \geq \delta d_t,$$

where δ is the required reserves coefficient. Finally, we assume that leverage is limited:

$$z_t \leq \chi n_t,$$

where the bank's capital, n_t, is given by

$$n_t = f_t + z_t - d_t - x_t.$$

The leverage ratio χ, which could be time varying, is the key innovation of this model relative to Edwards and Végh (1997) and others (such as Catão and Rodriguez, 2000). One could rationalize the leverage constraint as a shortcut to modeling agency problems of the type emphasized by Kiyotaki and Moore (1997) and, more recently, Gertler and Karadi (2009). We assume χ is greater than one, and reflects either regulation or agency issues.

Finally, $\xi_t \eta(z_t, d_t)$ is the resource cost of "producing" deposits and credit. We use the functional form for $\eta(.)$ proposed by Edwards and Végh (1997), but introduce a parameter κ that determines the weight of firm credit in the bank's cost function:

$$\eta = \sqrt{\kappa z^2 + (1-\kappa) d^2}.$$

Assume that the reserve requirement holds with equality, and let θ_t be the multiplier of the leverage requirement. The first-order conditions are

$$(1-\delta) - \xi_t \eta_2(z_t, d_t) - \theta_t \chi (1-\delta) = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^d - \delta \frac{P_t}{P_{t+1}}),$$

$$1 - \theta_t \chi = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t), \qquad (4)$$

$$1 + \xi_t \eta_1(z_t, d_t) - \theta_t (\chi - 1) = \beta E_t \frac{\lambda_{t+1}}{\lambda_t}(1 + r_t^l).$$

The model is closed by a specification of government policy. Clearly, we have set up the model so that we can discuss the effects of unconventional policy on allocations and prices, including the volume of bank intermediation and credit spreads.

For now, assume the simplest: the government rebates to households the gains from imposing reserve requirements. Also, assume that $\xi_t \eta(z_t, d_t)$ is paid to the government as in Edwards and Végh (1997), perhaps because it represents monitoring services. Then

$$T_t = f_t - f_{t-1}\frac{P_{t-1}}{P_t} + \xi_t \eta(z_t, d_t).$$

To finish, we need a specification for inflation policy. Here the government controls $P_t/P_{t-1} = \Pi_t$. This matters, despite flexible prices, because required reserves are paying the inflation tax. With these assumptions, in equilibrium, the economy's overall constraint reduces to

$$(1 + r_{t-1})x_{t-1} = A_t l_t - c_t + x_t,$$

whose interpretation is clear: the repayment on foreign borrowing is equal to the trade surplus plus new borrowing.

Finally, we need to make an assumption about the world interest rate r_t. For now, assume it is constant at r^*. Also, we will assume $\beta(1 + r^*) < 1$. The need for this becomes apparent upon examination of the nonstochastic steady state. In steady state, the bank's optimality condition for the amount to borrow in the world market, given by equation (4), reduces to

$$1 - \beta(1 + r^*) = \theta\chi. \qquad (5)$$

As we are about to solve for a linear approximation of the dynamics around the steady state, we need to make a decision as to whether the leverage constraint binds in steady state. We will assume that it does, which requires that θ be strictly positive in steady state. Hence $\beta(1+r^*)$ must be less than one.

The interpretation of the Lagrange multiplier, θ, is illuminating: it is the shadow cost to banks of the leverage requirement. Accordingly, if the leverage coefficient χ increases, θ must fall. This is natural, since a higher χ allows banks to increase leverage.

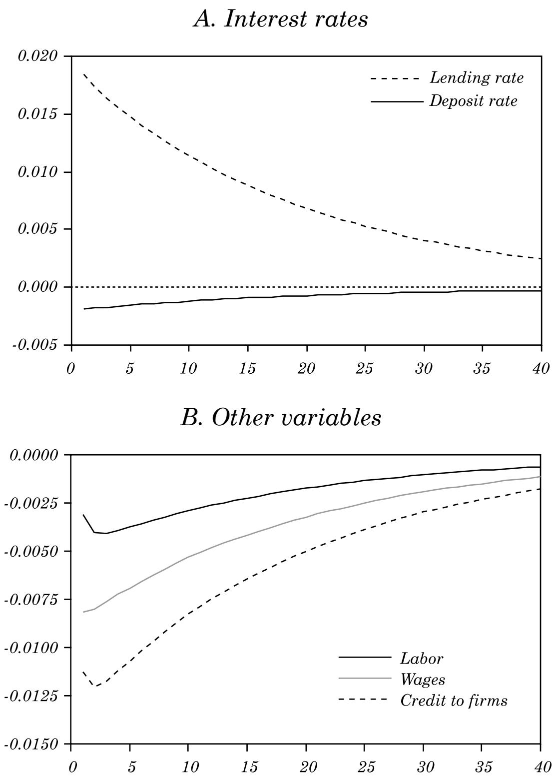
The model can be calibrated and solved in the usual way. Then one can examine the implications of alternative policies of interest. For illustrative purposes, we assume a world interest rate of 2 percent, a reserve requirement coefficient (δ) of 10 percent, and a leverage ratio (χ) equal to 3. The household's deposit requirement (α) is assumed to be 0.2 while the fraction of the wage bill that firms must borrow is assumed to equal 0.5. The remaining parameters are presented in table 1. Our parametrization implies that the steady state lending-deposit interest rate spread is equal to 7.7 percent. In the steady state, the economy's external debt makes up 30 percent of total lending to firms, deposits 41 percent, and the remainder is financed with the banks' own net worth.

Table 1. Parameter Values

Parameter	*Description*	*Value*
δ	Reserve ratio requirement	0.10
χ	Leverage ratio	3.00
α	Household deposit requirement	0.20
γ	Fraction of wage bill firms must borrow	0.50
β	Discount factor	0.971
r_t	World interest rate	0.02
κ	Weight on firm credit in bank's costs	0.80
ϱ	Policy rule parameter	−2.00
Π	Inflation rate (P_{t+1}/P_t)	1.00
ρ_A	Persistence of shock to A	0.95
ρ_ξ	Persistence of shock to ξ	0.95
ρ_r	Persistence of shock to r	0.95

To evaluate the dynamics of the economy, we study the impulse response functions of the model's main variables in response to shocks to the world interest rate and banking costs. Figure 1 displays the impulse responses of the calibrated model to a 1 percent shock to the bank cost ξ. As Edwards and Végh (1997) stress, this can be interpreted as a domestic shock—a change in regulation or shocks to the underlying banking technology—or as an external shock, such as an international financial crisis. Panel A shows that a shock to the bank's cost function is associated with an increase in the real lending rate and a fall in the deposit rate. The increase in banking costs increases the marginal cost of extending credit. On the deposit side, the increase in producing deposits reduces the deposit rate paid to consumers. This reduction in the deposit rate increases the price of consumption. On the lending side, the increase in the marginal cost of producing loans increases the lending rate. In equilibrium, the lending spread increases. This is in line with intuition and is consistent with Edwards and Végh's discussion. Panel B shows that the result is an aggregate contraction, expressed in a fall in credit and, concomitantly, labor employment and wages.

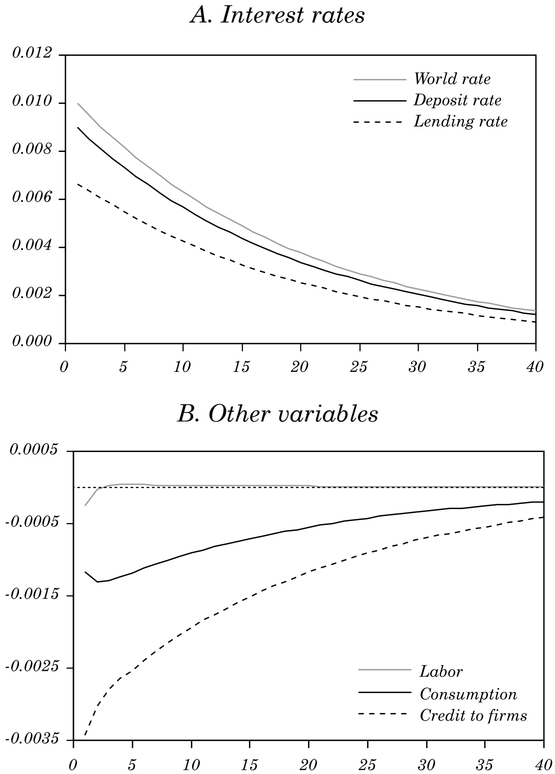
Figure 1. Adjustment Paths Following a Shock to Bank Costs



Source: Authors' calculations.

Figure 2 displays impulse responses to a one-hundred-basis-point increase in the world interest rate. Panel A shows that both domestic lending and deposit rates increase as a result. Interestingly, deposit rates increase more than lending rates, such that the spread between the two shrinks. The increase in the world interest rate increases the cost of external borrowing. Banks will try to substitute this external lending by increasing the deposit rate. The lending rate increases, but by less than the deposit rate, as the higher world interest rate has a negative wealth effect on the economy that reduces consumption and lending in equilibrium. Panel B shows that credit and consumption fall persistently. Besides a small initial drop, labor employment is essentially unaffected.

Figure 2. Adjustment Paths Following a Shock to World Interest Rates



Source: Authors' calculations.

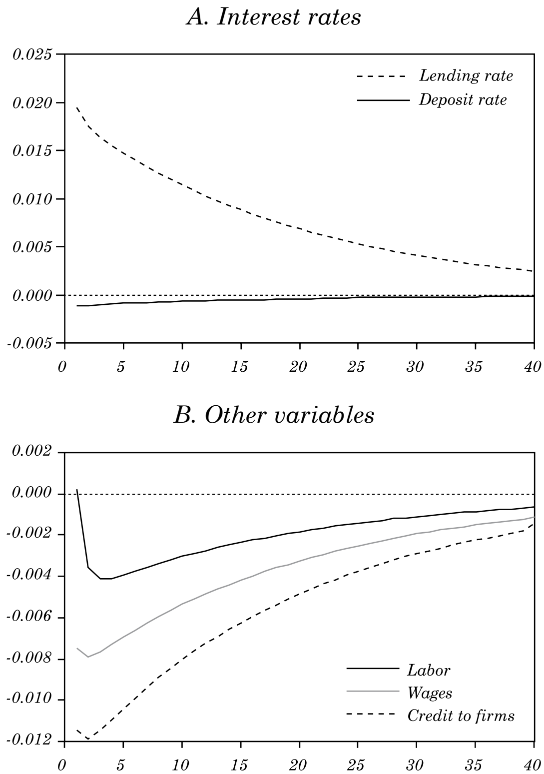
In this model, we can examine the effects of different unconventional policies. For example, one might conjecture that a policy of reducing reserve requirements when spreads increase could be stabilizing. To analyze this conjecture in our model, we drop the assumption of a constant δ, and assume instead that

$$\delta_t = \overline{\delta} + \varrho(r_t^l - r_t^d),$$

where $\overline{\delta}$ is the steady state value of δ_t and ϱ governs the sensitivity of the reserve coefficient's response to the domestic spread.

Figures 3 and 4 display the impulse responses to the same shocks as those presented in figures 1 and 2, namely shocks to the banking

Figure 3. Adjustment Paths Following a Shock to Bank Costs When the Reserve Requirement is Endogenous

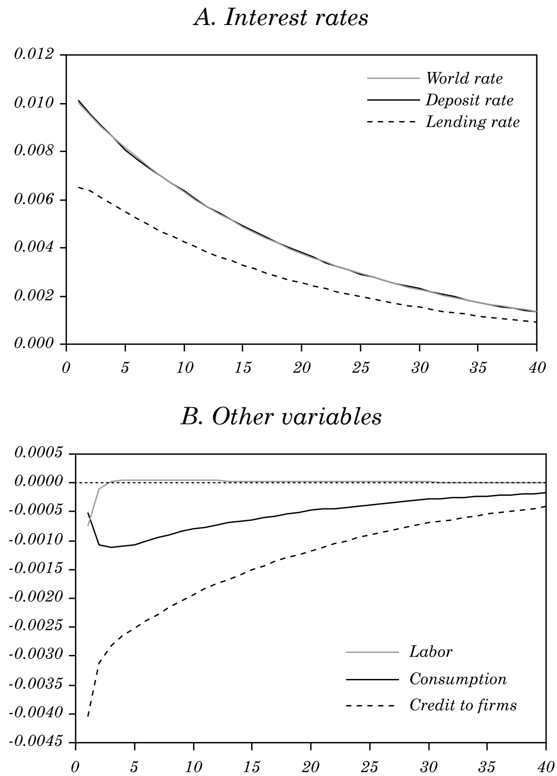


Source: Authors' calculations.

cost function and to the world interest rate. Panel A in figures 1 and 3 are quite similar, suggesting that reducing reserve requirements in response to increases in the domestic spread may have little impact on deposit and lending rates. Comparing panel B in figures 1 and 3, however, reveals that this policy significantly stabilizes credit and labor employment on impact, although for this parametrization the stabilizing effect lasts for only one period. The reduction in the reserve requirement slightly mitigates the impact of higher marginal costs in the production of deposits and loans.

Figure 4, panel A shows that the reserve requirement policy also has negligible effects on the response of domestic interest rates

Figure 4. Adjustment Paths Following a Shock to World Interest Rates When the Reserve Requirement is Endogenous



Source: Authors' calculations.

to an increase in the world rate. Panel B, however, shows that the policy has somewhat surprising real effects: credit falls by more and consumption by less than without the policy. The reason is that the policy rule makes δ_t increase—not fall—in response to an increase in the world interest rate: such a shock makes domestic lending rates and deposit rates increase, but their difference falls.

There are a number of lessons here. The effect of an "obvious" policy is not obvious and depends delicately on the details of both model and policy. However, our model clarifies and provides useful information about the different channels. For example, given our discussion, one could conjecture that the problem is that δ_t is responding to the domestic spread, but that it may be better for δ_t to respond to the international spread instead, such that

$$\delta_t = \overline{\delta} + \varrho(r_t^l - r_t),$$

where r_t is the world rate of interest. But here such a change is probably of little help, because r_t^l increases by less than r_t in response to a shock to the latter, and hence δ_t would also increase (perversely) with the modified policy.

More generally, the model here is an example of the kind of theory that needs to be developed to be able to discuss consistently the unconventional policies that have been implemented in practice. Only with this kind of framework can we trace the effects of policies that respond to interest rate spreads or prescriptions to inject equity into banks. In contrast, standard models are silent about these issues, because their assumption of a perfect financial market clouds perception of financial intermediation.

2. Heterodox Monetary Policy: Recent Experience and Evidence

From the previous section, we have concluded that quantitative easing—outright purchases of assets by the central bank and changes in the central bank portfolio—appears relevant only if it helps to increase the credibility of a given path for the monetary policy rate. We have also noted that it is premature to conclude that credit easing is useful as a policy in and of itself or as a commitment device for a particular monetary policy trajectory. Nevertheless, credit policy may be seen as necessary in the case of disrupted financial markets or as a complement to traditional monetary policy actions in particular cases.

With this in mind, we present some evidence regarding monetary policy actions in the recent financial crisis, as some countries reached the effective lower bound on nominal interest rates. We restrict our analysis to countries with some formal or quasi-formal inflation target to provide a more adequate comparison.

2.1 Recent Experience with Unconventional Monetary Policy

Starting with the subprime mortgage crisis, we have witnessed an unprecedented period of monetary policy activism. Even though the original trigger for the various kinds of interventions can be traced to the international financial crisis, the objectives and immediate motivations are somehow different. In the period prior to the fall of Lehman Brothers, monetary policy rates in most countries aimed to control inflation, which was running high due to high energy and commodity prices. At the same time, governments took actions to provide liquidity in foreign currency markets. After the Lehman bankruptcy, things changed. Liquidity provision intensified, while the rapid fall in commodity prices opened the door for aggressive cuts to interest rates. In this period, some central banks also implemented credit policies to address malfunctioning financial markets. As interest rate cuts intensified, some countries reached a lower bound for the monetary policy rate. At this point, we saw some central banks implementing additional unconventional policies to reinforce the credibility of the announcement that interest rates would be kept low for a long time.

2.1.1 The pre-Lehman-bankruptcy period

The outbreak of the mortgage-backed-security crisis was the beginning of a period of significant tensions in financial markets around the world. These tensions were initially limited to the United States and the United Kingdom, but expanded to other developed economies during the first half of 2008. In most cases, they led to the need to inject significant amounts of liquidity in foreign currency markets. The basic objective of the liquidity provision measures was to reduce pressure on short-term U.S. dollar funding markets. In particular, from September 2007 to September 2008, many central banks implemented different varieties of U.S. dollar repurchase transactions. Sometimes these operations were complemented by reciprocal swap agreements between the U.S. Federal Reserve and other central banks.

In the same period, monetary policy in most central banks focused on dealing with rising inflation due to the shock from commodity prices. In fact, during this period many countries increased interest rates as they implemented measures to inject liquidity in domestic financial markets. Nevertheless, those countries most exposed to the subprime mortgage crisis—Canada, the United Kingdom, and the United States—started reducing policy interest rates as credit conditions tightened and the macroeconomic outlook worsened.

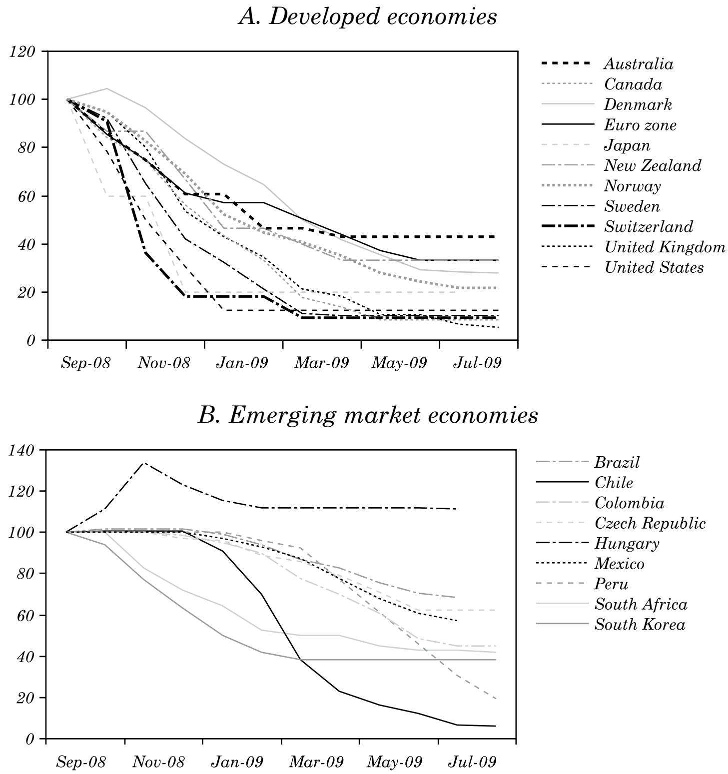
2.1.2 The post-Lehman-bankruptcy period

The Lehman Brothers bankruptcy in September 2008 triggered a new phase in monetary policy. The demand for liquidity intensified significantly, causing central banks around the world to either introduce or intensify previous efforts to provide liquidity.

This is also the period in which we started to observe a clear shift towards an expansionary monetary policy stance. With inflationary pressures subsiding due to a marked decline in energy and other commodity prices, and the intensification of the financial crisis that increased the downside risks to growth and thus to price stability, some easing of global monetary conditions was warranted. In line with this outlook, a group of countries aggressively cut the monetary policy rate in the fourth quarter of 2008, as shown in figure 5. Others stopped raising interest rates due to the worsening economic outlook. An additional signal of the perceived magnitude of events facing the world was the unprecedented joint action taken by a group of major central banks on 8 October 2008: a coordinated cut to interest rates. This measure involved the Bank of Canada, the Bank of England, the European Central Bank, the Federal Reserve, the Sveriges Riksbank, and the Swiss National Bank. The Bank of Japan expressed its strong support.

During this period, financial conditions deteriorated markedly. The combination of high uncertainty, lower growth perspectives and commodity prices, and the worsening international financial conditions gave rise to very restrictive credit conditions. Lending spreads increased significantly, as shown in figure 6, and credit to firms became quite scarce. In this scenario, many central banks

Figure 5. Monetary Policy Rates Since Lehman

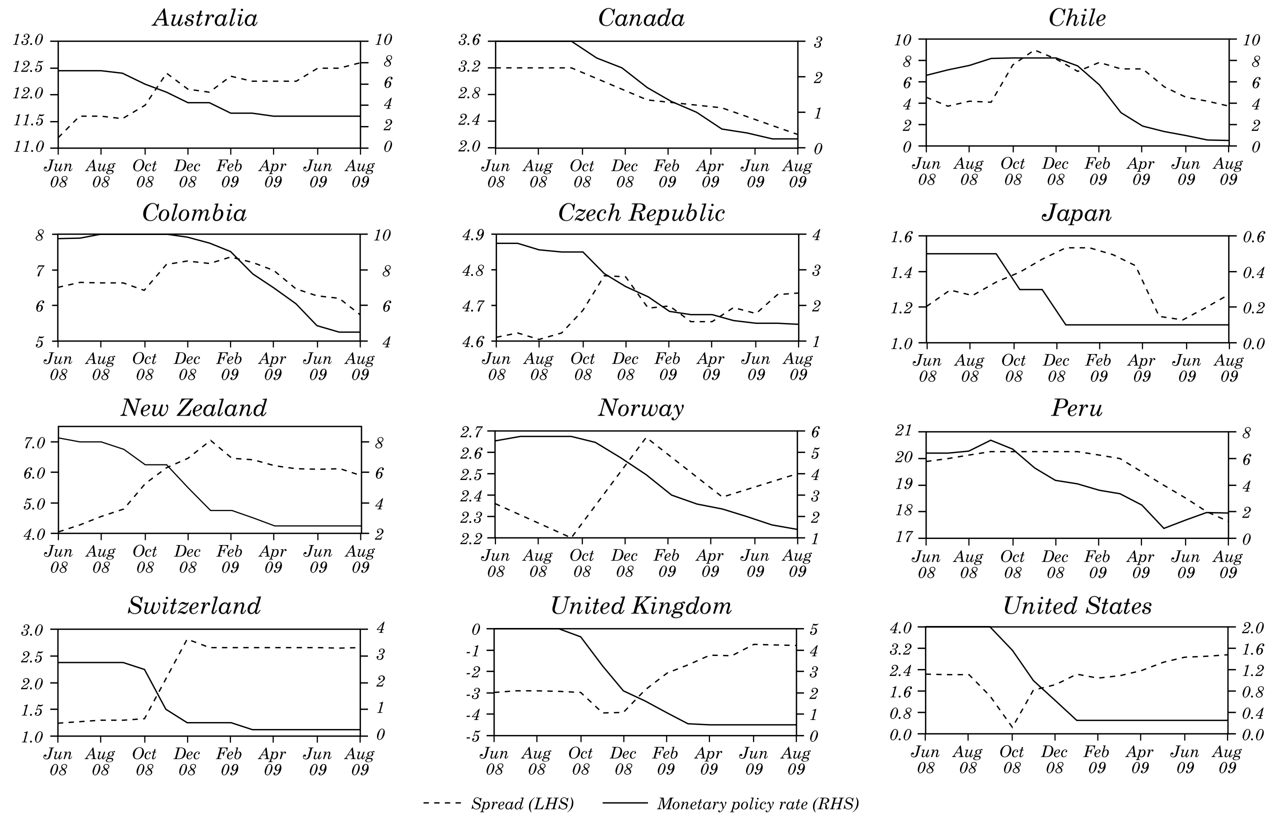


Sources: Bloomberg and national central banks.

contemplated the possibility of disruptions in the monetary policy transmission channel. This explains why, in some cases, monetary policy focused initially on restoring the functionality of financial market rather than on reducing interest rates. Also, some countries did not reduce interest rates until it was clear that inflation pressures had been mitigated. As commodity prices started to fall in the last quarter of 2008, inflation also plunged.

In the scenario of tight credit conditions, some countries implemented asset purchase programs, while others started lending to banks, accepting commercial paper as collateral. The asset purchase programs sought to push up the price of Treasury bills. For countries with more severe financial market disruptions, the asset purchase programs involved buying private assets directly (for instance, in the

Figure 6. Lending-Deposit Spread and Monetary Policy Rates[a]



Sources: Bloomberg and national central banks.

a. The left axis indicates the lending-deposit spread; the right axis plots the monetary policy rate. The data for Canada and Norway are quarterly.

United States and the United Kingdom) or through special funds (for instance, in South Korea and Switzerland). Now, the most common action to improve the supply of loans to the corporate sector was to expand the list of acceptable collateral in operations with the central bank to include commercial paper, corporate securities, asset-backed securities, mortgage securities, and securities with lower credit ratings. In some cases, the easing of collateral requirements was complemented by the introduction of special credit facilities to eligible financial institutions against selected collateral, mainly commercial paper. Additionally, some central banks broadened eligible counterparties for liquidity provision operations.

As of January 2009, all central banks in our sample had started lowering their policy interest rates. At that point it became clear that the deterioration in world activity, the reduction in commodity prices, and more negative output gaps were giving rise to deflationary concerns. Many central banks revised their inflation forecasts downward by significant amounts. As a result, actions to inject liquidity to financial markets continued, but liquidity concerns subsided. Instead, the focus of monetary policy shifted to the financial crisis' effects on economic activity. Some countries also hit the lower bound in this period and implemented measures to deal with this problem.

At this point, some countries engaged in exchange rate intervention. In particular, and in line with the search for ways to deal with the lack of monetary policy stimulus at the lower bound, developed countries started buying dollars to avoid further appreciation of their currencies. Additionally, some central banks started buying bonds issued by private-sector borrowers. One special feature of these interventions was that many central banks stated clearly that unconventional measures did not compromise medium- and long-term price stability.

Even though some central banks recognized that financial systems were well prepared to face the turbulence, the financial crisis' effect on credit provision was evident. As mentioned before, that led some central banks to establish loan facilities to increase access to credit with longer duration.

Tight credit conditions led many central banks to open new facilities to financial intermediaries, to stimulate bank lending to non-financial companies. Many central banks were concerned about direct lending. The Riksbank stated on 28 November that it "should not lend directly to non-financial companies, because that would be a departure from the Riksbank's traditional role as the banks' bank."

That position led the Riksbank to lend to financial intermediaries instead of lending directly to non-financial firms.[4]

For the group of countries that reached the lower bound, in addition to announcing this fact, a new communication instrument joined the traditional monetary policy announcement: central banks indicated that the interest rate was going to be kept at that level for a long time. Moreover, some central banks opened credit facilities at fixed rates with maturities consistent with the announcement that the monetary policy rate would remain at the lower bound for a prolonged period of time. This was a clear indication that central banks were using mechanisms to increase the credibility of their announcements.

Regarding the period of time during which interest rates were going to be kept constant, some central banks were very explicit (beyond those that had already published their monetary policy rate path). For example, the Bank of Canada announced in April 2009 that it was cutting its monetary policy rate to 0.25 percent and committed to holding that rate until the end of the second quarter of 2010. Other central banks announced exchange rate interventions to prevent any appreciation of the exchange rate or to restore the level of foreign currency reserves.

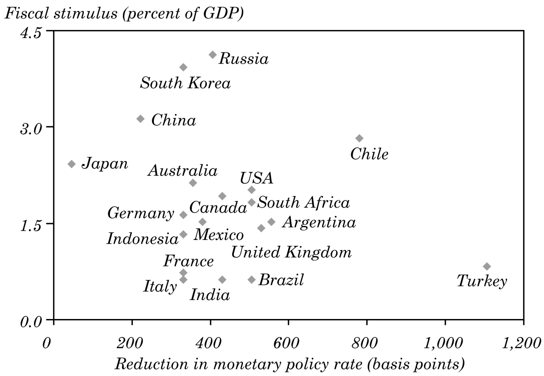
Finally, it is worth noting that most of the aggressive policies implemented by central banks were followed by important fiscal stimulus packages, as figure 7 illustrates for a selected group of countries.

2.2 Alternative Measures of Monetary Conditions

As we have seen, central banks around the world have recently engaged in many unconventional operations. Excluding those exclusively oriented to restoring liquidity, we can associate other measures with the need to reinforce monetary policy stimulus to the economy, particularly in the presence of the lower bound, and with the need to unlock financial markets, a key channel of the monetary policy transmission process. In normal times, changes in the monetary policy rate are generally used as a sufficient statistic to describe the monetary policy stance. This practice presents a challenge when this rate reaches its lower bound and it is interesting to analyze different measures to characterize monetary conditions. In the next section, we describe a number of exercises trying to quantify

4. They did so by offering loans to banks using commercial paper as collateral.

Figure 7. Fiscal Stimulus and Monetary Policy Rates



Sources: Bloomberg, national central banks, and ministries of finance.

the monetary policy stance after September 2008. In particular, we analyze the size and composition of central bank balance sheets, and the Monetary Conditions Index. We then go on to evaluate the effectiveness of unconventional monetary policy actions. Before going into this exercise, we will present estimations for the monetary policy interest rates implied by Taylor rules. From this exercise we can evaluate the potential magnitude of the need to generate additional monetary policy stimulus at the lower bound.

2.2.1 Taylor rules

To evaluate the need for monetary policy stimulus we perform a simple exercise in which we compare the observed behavior of monetary policy rates against the path implied by a Taylor rule. For countries that have reached the lower bound, the difference between these two paths can indicate that a further monetary impulse is warranted. We proceed by estimating a rule where the current value of the monetary policy rate responds to a three-month-lagged value of this rate, the output gap (measured as a deviation from a Hodrick-Prescott (HP) trend) and the annual rate of inflation in the consumer price index.[5] Additionally, we also consider the possibility

5. The results are robust when using deviations of observed inflation from the target, for those countries that announce an explicit target.

of the policy rate reacting to either nominal (against the U.S. dollar) or real (multilateral) annual exchange rate depreciations. The estimation was performed using data until 2007, and the resulting coefficients were used to compute the implied paths for the Taylor rule from that date onward.[6]

Columns three to five in table 2 display the percentage reduction in the policy rate obtained for different specifications of the Taylor rule estimated from September 2008 to the last available observation, while the second column reports the actual change for comparison. The results do not show a clear pattern. Only for Japan, Sweden, Switzerland, the United States and, to a lesser extent, the euro area, does the Taylor rule indicate a bigger reduction than was actually observed.[7] For the other countries, the predicted changes in these three columns either approached or were significantly smaller than actual reductions.

A concern about the results based on a rule that contains a smoothing parameter is that this backward-looking component may not be appropriate to describe behavior when the lower bound is binding. One would expect this coefficient to change (probably moving closer to zero) as the rate approaches the lower bound—particularly in a period of sudden financial distress—since the monetary authority will be less concerned about reducing the volatility in interest rates than in regular times. One way to control for this effect is to use a long-run Taylor rule in which the interest rate depends solely on inflation and the output gap. The coefficients for these variables are those estimated in the baseline case and adjusted by $(1- \rho_i)$, with ρ_i being the estimated coefficient on the lagged policy rate. That is, if the originally estimated rule is

$$i_t = \rho_i i_{t-1} + \rho_\pi \pi_t + \rho_y \tilde{y}_t,$$

then the long-run effect of a change in π_t and $\tilde{y}_t$ are, respectively, $\rho_\pi/(1 - \rho_i)$ and $\rho_{\tilde{y}}/(1-\rho_i)$, provided $|\rho_i|<1$. In this way, this alternative

6. We used the iterative generalized method of moments for the estimation, using as instruments the lagged values of the regressors and current and lagged values of oil prices and the Commodity Research Bureau commodity price index. In an attempt to make results robust to the lag selection for the instruments, we estimated each equation using from two to twelve lags for monthly data (one to four for quarterly), and use the median across the different alternatives of each coefficients to make the out-of-sample forecast.

7. Rudebusch (2009), for instance, finds a similar result for the United States, although using forecasts from the Federal Open Market Committee meetings to compute the predicted path instead of actual data as we do.

Table 2. Taylor Rules[a]
Percentage reduction

Country	*Data*	*Baseline, nominal exchange rate*	*Baseline, real exchange rate*	*Baseline, nominal exchange rate*	*Long-run, nominal exchange rate*
Australia	50	32	31	30	71
Canada	92	90	84	84	171
Chile	88	59	58	58	104
Colombia	51	40	42	43	102
Euro zone	67	81	67	68	288
Japan	80	108	112	112	150
New Zealand	49	9	9	9	41
Norway	72	50	51	54	17
South Korea	62	55	55	55	30
Sweden	89	126	127	124	260
Switzerland	99	103	117	103	149
United Kingdom	90	85	85	81	101
United States	88	128	128	–	347

Source: Authors' calculations.
a. Data are monthly and run from September 2008 to August 2009 for all countries except the following: Australia, New Zealand, and Switzerland (quarterly data, ending in the first quarter of 2009); and Canada, Japan, and South Korea (quarterly data in the case of rules including the real exchange rate). Chile was estimated using data from July 2001 on, to account for the change in the policy instrument. The long-run Taylor rule applied involved multiplying coefficients for the output gap and inflation by $1/(1-\rho_i)$, with ρ_i being the estimated coefficient on the lagged policy rate.

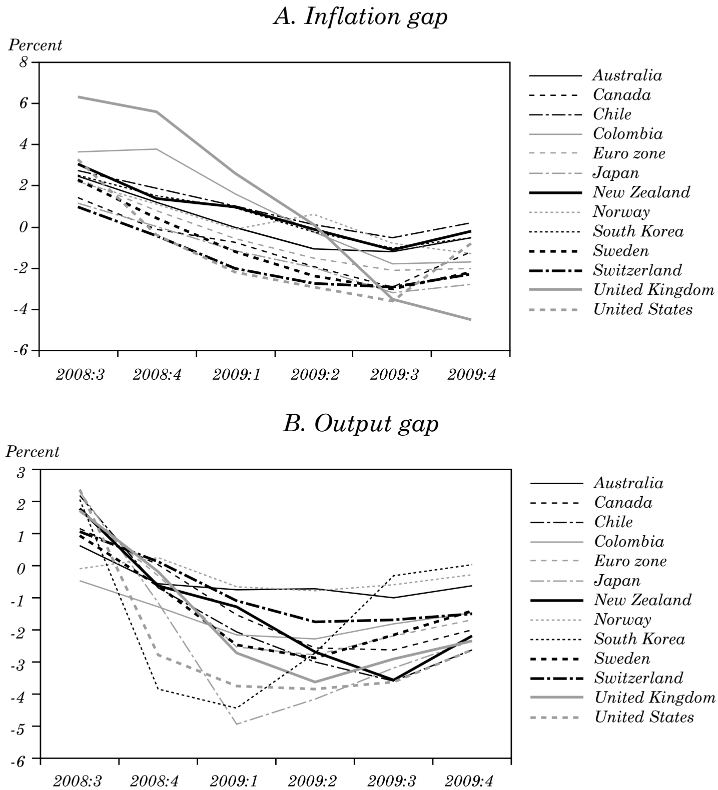
assumes that the response to inflation and the output gap is the same as historically described, once we adjust for the persistence of interest rates.

The sixth column in table 2 computes the implied reduction using the long-run rule.[8] With a few exceptions, results appear more conclusive in this case: the long-run rule recommends a much lower rate than the observed one. For instance, if we compute the average reduction that this rule implies for countries that have maintained a low policy rate, we obtain a reduction of 140 percent, while this same statistic for the other countries (not shown in the table) is 46 percent. Additionally, it is interesting to notice that for those countries that have decreased and maintained the rate at a low level but at a value significantly greater than zero (such as Australia, New Zealand, Norway, and South Korea), the Taylor rule implies—with the exception of Australia—that the policy rate should be above its actual level. In particular, the average observed reduction within this group was 58 percent, while the rule suggested an average reduction close to 40 percent. Moreover, these are the only countries in this sample for which this long-run rule would not have predicted a negative interest rate. On the other hand, for those that have reached a bound close to zero, the mean observed reduction was 83 percent, while the Taylor rule suggested a drop of nearly 186 percent, on average. In particular, the biggest differences between the actual change in the policy rate and that implied by the rule are for the United States, the euro area and Sweden, while for Chile, Colombia and the United Kingdom the rule would have recommended driving the rate to a value just below zero.

To check for the robustness of our results we do a simple exercise in which we compute a common-parameter Taylor rule for the countries under analysis. In particular we compute an implicit monetary policy rate from the following Taylor rule: $i_t = i + \rho_\pi(\pi_t - \pi) + \rho_y \tilde{y}_t$, where i corresponds to the average rate in the past 10 years, and π corresponds to the inflation target. This is equivalent to having a common central banker for these countries. We use quarterly output data to obtain a common measure of activity. In figure 8 we show the arguments of our Taylor rule: the deviation of inflation from the target and the output gap. The output gap is computed using the HP filter.

8. Results are similar if we include measures of exchange rates in the rule.

Figure 8. Deviation of Inflation from Target and Output Gap



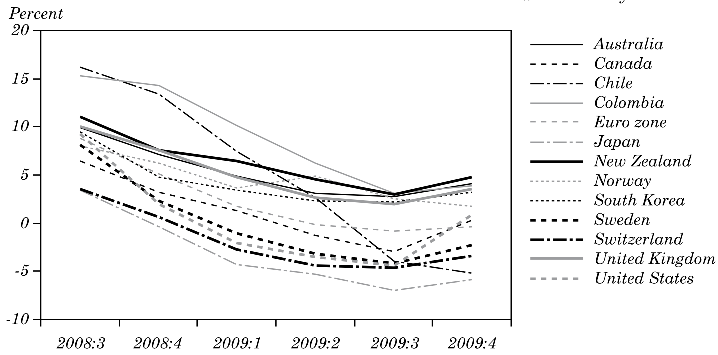
Source: Authors' calculations.

As can be seen, all the countries in our sample had inflation rates above the inflation target prior to September 2008.[9] This is consistent with monetary policy rate management before the Lehman bankruptcy. In some cases, this deviation persisted at a lower intensity through the last quarter of 2008. Nevertheless, the general picture is that inflation plunged below target after the third quarter of 2008, in most cases between the fourth quarter of 2008 and the third quarter of 2009. Furthermore, all countries in the sample were experiencing a negative output gap by the first quarter of 2009.

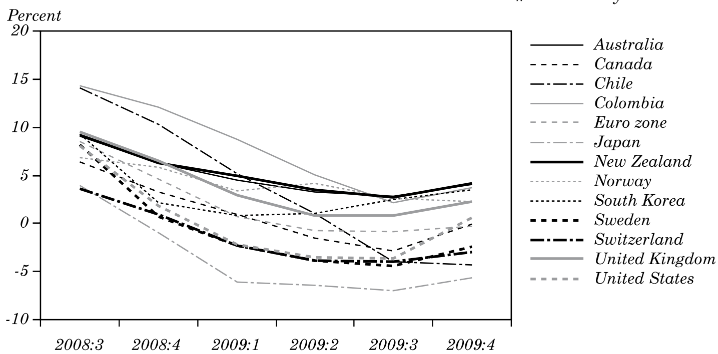
9. In the cases of the United States and the euro area, we use implicit targets of 2 percent and 1.5 percent, respectively.

Figure 9. Monetary Policy Rate Implied by Common-Parameter Taylor Rules

A. MPR Taylor rule (common parameters) ρ_π=1.75, ρ_y=0.5



B. MPR Taylor rule (common parameters) ρ_π=1.25, ρ_y=1.00



Source: Authors' calculations.

Next, we use the previous information to estimate monetary policy rates for two different Taylor rules, presented in figure 9. The results indicate that our common-parameter monetary policy rate was negative or just above zero at some point in time for all the countries that reached the lower bound. Only the euro zone exhibits a negative estimated monetary policy rate, while the effective interest rate is significantly higher than zero.

This exercise clearly does not take into account the forward-looking nature of monetary policy. However, it is useful to note that the rapid deterioration in the economic environment called for a swift monetary policy reaction, like the one observed, and that countries reaching the lower bound needed significant additional monetary policy stimulus.

2.2.2 Balance sheets

For those countries that reached the lower bound and, more generally, those countries implementing unconventional monetary policy actions, the interest rate is not the only—and perhaps not the best—aggregate indicator of monetary policy actions. In principle, an alternative way to quantify the monetary policy impulse is to examine the evolution of monetary aggregates. However, given that most policies implemented during this current crisis entailed more than simply printing money, it is probably more appropriate to look at the evolution and composition of the central bank's balance sheet. Moreover, we have argued that the size and composition of the central bank balance sheet can be relevant to dealing with lack of credibility arising at the lower bound, at least from a theoretical perspective.

For those countries that reached a bound as they dropped policy rates, table 3 shows the percentage change in total assets, liabilities, and capital—that is, assets minus liabilities—comparing both the mean values in 2007 with those of August 2008, and the change from August 2008 to September 2009. Except for Australia, all these countries have increased their asset positions since August 2008. The mean and median of these changes reached 56 percent and 20 percent, respectively. In addition, it also seems that after September 2008, total asset growth accelerated over the recent past, with the sole exception being the European Central Bank, whose assets increased proportionately more in early 2008. The most dramatic increases occurred in Sweden, the United Kingdom, and the United States. Liabilities posted a similar, rising trend.

Another potentially useful measure involves central bank capital. On one hand, one can argue that increasing the capital level may be useful in coping with a financial crisis, for it might, for instance, reduce the likelihood of a run against the local currency. On the other hand, however, a possible way to increase the expectations about future inflation to deal with a zero bound situation is to increase the size of bank liabilities proportionally more than asset holdings. For instance, if the central bank is concerned with its level of capital at some point, it will have incentives to produce inflation in the future. In this sense, it is not clear what the policy

Table 3. Central Bank's Assets and Liabilities
Percentage change

	Assets		*Liabilities*		*Capital*	
Country	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*	*Mean 2007 to Aug 2008*	*Aug 2008 to Sept 2009*
Australia	−6.8	−2.9	−7.2	−3.5	0	5.5
Canada	10.6	33.7	10.4	33.9	116.8	−11.3
Chile	25.0	41.9	20.7	19.2	2.9	138.2
Colombia	0.8	17.9	12.3	14.7	−28.3	30.8
Euro zone	11.0	1.6	11.1	0.8	9.7	12.9
Japan	−2.7	6.4	−3.0	6.7	1.8	0.8
New Zealand	12.8	18.6	−84.8	−6.3	793.5	22.0
Norway	6.7	18.0	−6.5	2.4	11.9	23.2
South Korea	10.2	19.3	−10.8	16.6	680.5	33.1
Sweden	−0.1	240.9	−1.7	334.6	4.0	9.0
Switzerland	17.7	50.2	43.9	84.6	−4.7	5.9
United Kingdom	2.7	142.8	4.0	146.1	−30.5	11.7
United States	1.4	139.8	0.7	145.2	18.3	26.5

Source: National central banks.

recommendation should be during a crisis like the recent one. The evidence presented in table 3 suggests that central banks decided to increase the value of their capital after August 2008. The only exception is the Bank of Canada, whose capital has fallen by nearly 11 percent, although the value of its capital had more than doubled in the first part of 2008. Also, the Bank of Japan has presented a mild increase in assets over liabilities (under 1 percent) since August 2008. At the other extreme, the Central Bank of Chile increased its capital by more than 100 percent, breaking a downward trend apparent in previous years.

While the size of the central bank's balance sheet may be a good approximation for its monetary policy stance, portfolio composition offers another dimension worth considering, given that most unconventional policies involved buying assets that are not part of the usual holdings. Table 4 presents a simple breakdown of the asset side of central bank balance sheets. For most countries, the table shows the shares of foreign assets, domestic credit to the government (mainly composed of Treasury bonds) and other domestic credit.[10] To better understand the size of these changes, for each country the table displays the mean in 2007 and compositions in August 2008 and September 2009.

The evidence does not show a clear pattern in the actions taken by these central banks. Some countries do not appear to have significantly changed the composition of their assets during the sample. This is the case for Japan, the euro area and, to a lesser extent, Australia, which decreased its foreign assets in favor of other domestic credit in early 2008, but reversed the change in the latter part of the sample. For others, the change has been more dramatic. In most cases, central banks have reduced the share of foreign assets in their portfolio. Exceptions are Canada, which continues to hold a negligible amount of foreign assets and has increased domestic credit to the private sector while reducing its holdings of government assets, and Colombia, which has increased this share by almost ten percent since 2007 by reducing both components of domestic credit. South Korea and Switzerland have increased their holdings of government assets proportionally more, while New Zealand, Norway, and Sweden significantly raised domestic credit to the private sector.

10. We present a different breakdown for the United Kingdom and the United States, details of which are explained in a footnote to table 4.

Table 4. Central Bank Asset Composition

				Domestic credit					
	Foreign assets			*Government*			*Other*		
Country	*Mean 2007*	*August 2008*	*September 2009*	*Mean 2007*	*August 2008*	*September 2009*	*Mean 2007*	*August 2008*	*September 2009*
Australia	59.2	47.5	59.8	0	0	0	39.5	51.1	38.8
Canada[a]	0	0	0	95.7	96.5	61.2	3.8	0.1	38.4
Chile	78	80.5	69.7	0	0	0	15.8	11.3	9.9
Colombia	74.5	85.2	82.1	3.5	0.4	0.7	11.1	3.6	6.9
Euro zone	23.9	23.4	20	11.1	10.4	11.9	56.7	57.3	57.7
Japan	4.6	5	4.8	65.5	60.9	58.5	28.8	32.9	35.6
New Zealand	77.7	67	61.9	20.2	17.9	12.1	1.8	0	25.7
Norway	14.9	10.4	9.9	82.9	85.6	87.4	2	1.8	2.6
South Korea	93.5	93.6	83.9	4.3	4.6	10	2.2	1.7	6.1
Sweden	94.8	97.5	50.5	0	0	0	3.2	0.6	48.5
Switzerland	70.9	59.4	60.1	0	0	10.9	28.3	39.8	28.6
United Kingdom[b]	26.3	36.5	0	20.9	23.6	17.4	52.8	39.8	82.6
United States[c]	87	53.6	35.9	0	0	38.4	4.1	29.1	21.9

Source: National central banks.
a. For Canada, foreign assets are just foreign currency deposits.
b. For the United Kingdom, the columns are, respectively, short-term repos, long-term repos and bonds, and other.
c. For the United States, the columns are, respectively, Treasury securities, other securities held outright, and all liquidity facilities.

Finally, in terms of the countries with a different breakdown, both the Federal Reserve and the Bank of England have drastically altered the composition of their assets. For the former, the shares of U.S. treasuries decreased by more than 50 percent, increasing instead the portion devoted to other overnight securities and liquidity facilities, which by 2007 represented a negligible part of its portfolio. The Bank of England posted a striking reduction in short-term repos to almost zero, which were replaced by a rise in bonds and other domestic credit.

2.2.3 The Monetary Conditions Index

An additional measure of monetary expansivity that we explore is the Monetary Conditions Index (MCI), which became popular in the mid-1990s for its use at the Bank of Canada and the Reserve Bank of New Zealand, among others.[11] The idea of this index is that the monetary policy stance cannot be properly captured by looking at the monetary policy rate alone—particularly for a small open economy—and that the real interest and exchange rates better summarize monetary conditions. This index is calculated as

$$MCI_t = \omega(r_t - r_0) + (1 - \omega)(q_t - q_0),$$

where r_t is the interest rate, q_t is the real exchange rate (an increase is an appreciation), r_0 and q_0 are the values in the base year, and ω is the relative weight on the real interest rate.[12] Therefore, a rise in the index implies a tighter monetary condition. Although the usefulness of this index has been subject to debate (see, for instance, Stevens, 1998; Gerlach and Smets, 2000), most of the arguments for and against were based on analyzing "normal" times, so it is worth exploring its virtues to account for monetary conditions during a zero-bound period.

Table 5 presents the percentage change in the MCI between September 2008 and September 2009 for each of the countries that reached a lower bound in their policy rate. For comparison, we also report the historical mean and median annual change and the observed reduction in the policy rate. In general, the index has fallen significantly since September 2008. The exceptions are the United

11. See, for instance, Freeman (1995).

12. These weights are a function of the importance of these variables in explaining fluctuations in output. We followed the implementation suggested in Deutsche Bundesbank (1999).

Table 5. Monetary Conditions Index
Percentage points[a]

Country	*Change in the MCI*	*Historical annual change*		*Reduction in the MPR*
		Mean	*Median*	
Australia	−2.43	−0.03	−0.26	50
Canada	−1.23	−0.06	−0.11	92
Chile	−3.15	0.85	0.75	88
Colombia	−1.66	−0.45	0.20	51
Euro zone	−0.42	−0.05	−0.14	67
Japan	−0.04	−0.08	−0.12	80
New Zealand	−2.26	0.01	0.04	36
Norway	−1.58	0.12	−0.01	72
South Korea	−3.15	0.55	0.16	62
Sweden	−0.87	−0.14	−0.30	89
Switzerland	−1.02	0.06	−0.05	99
United Kingdom	−0.01	−0.01	−0.04	90
United States	2.41	−0.12	−0.05	88

Source: Authors' calculations.
a. Columns two and five are the percentage change between September 2008 and September 2009.

States, Japan, the United Kingdom, and the euro area.[13] Moreover, the size of the drop seems to be significantly bigger than the average size of the annual historical change in this coefficient, particularly in the cases of Australia, Chile, New Zealand, and South Korea.

2.2.4 Comparing the different measures

These alternative measures allow us to identify policy expansivity from different relevant perspectives. A final issue that we assess is the extent to which they reflect the same phenomena. To answer this question, table 6 shows the cross-country correlation between: the observed reduction in the monetary policy rate; the drop implied by the Taylor rule, both in its baseline and long-run specifications; the change in total assets and liabilities; the change in the share of other domestic credit and foreign assets between the average for

13. That the index does not perform properly in these countries is, in principle, not necessarily an important concern. As mentioned, the index was originally developed to represent the monetary stance of a small open economy, which is clearly not the case for these economies.

Table 6. Correlations of Different Measures of Monetary Expansion

	Drop in monetary policy rate	*Drop in Taylor rule*	*Drop in long-run Taylor rule*	*Rise in assets*	*Rise in liabilities*	*Change in share others*	*Change in foreign assets*	*Change in MCI*
Monetary policy rate	1							
Taylor rule	0.83	1						
Long-run Taylor rule	0.46	0.78	1					
Assets	0.52	0.63	0.50	1				
Liabilities	0.53	0.67	0.52	0.98	1			
Share others	0.28	0.41	0.32	0.72	0.70	1		
Foreign assets	−0.38	−0.57	−0.56	−0.87	−0.81	−0.61	1	
MCI	0.44	0.73	0.76	0.46	0.43	0.34	−0.57	1
LR TR — MPR	0.48	0.89	0.84	0.56	0.62	0.40	−0.58	0.78

Source: Authors' calculations.

2007 and September 2009; and the difference between the percentage reduction in the policy rate implied by the long-run Taylor rule and the observed reduction in that rate.[14]

The correlations between the observed drop in the monetary policy rate, the changes implied by the Taylor rule, the change in assets and liabilities, and asset composition all have the expected sign, except for the Monetary Conditions Index.[15] In particular, we can see a high correlation between changes in both assets and liabilities with the reductions implied by the Taylor rule, and with the difference between the rule-based and observed reductions. Both indicators for the change in the central bank portfolio composition also seem to be related to the changes implied by the Taylor rule, particularly with the change in foreign assets, which has historically been the most important part of central bank assets.[16]

2.3 On the Effects of Heterodox Policies

As a final exercise, we present some descriptive evidence of the effects that these unconventional policies have had on a set of variables relevant to monetary policy transmission, which have remained at center stage in policy discussions during the current crisis. In particular, we attempt to assess changes generated after policy announcements in the shape of the yield curve, and in lending-deposit spreads.

For a group of 12 central banks that reached a bound on their policy rates, we analyzed their press releases since mid-2007, identifying 56 policy announcements concerning unconventional measures.[17] For each of these events, we used daily data for government bonds at all available maturities to compute the slope of the yield curve one week before the announcement and one and two weeks after it, and then calculated the change in slope.[18] For the

14. These three are comparisons between September 2008 and the last available observation. For the United Kingdom and the United States, the items are those described in table 4.

15. These results for the MCI are robust if we exclude the euro area, Japan, the United Kingdom, and the United States.

16. Treasuries for the U.S. and short-term repos for the United Kingdom.

17. This group includes Australia, Canada, Chile, the euro area, Japan, New Zealand, Norway, South Korea, Sweden, Switzerland, the United Kingdom, and the United States.

18. Two different announcements can be part of the same event if they have occurred within two business weeks. While this is clearly not a rigorous econometric event study due to the limited size of our sample, this exercise should at least give us a rough idea of the impact of the announcement. A proper characterization of the causal effects of these policies is beyond the scope of this paper, mainly because not enough time has passed to have a relevant sample to attempt to measure them.

lending-deposit spread our data are more limited, and we computed the difference in the spread between its average one month before and one month after the announcement.[19]

To analyze results, we grouped announcements into five broad categories: asset purchases and direct lending to financial firms; expanding list of eligible collateral; paying interest on reserves; swap lines with other central banks; and term loan and/or liquidity facilities.[20] We also categorized the different yield curve slopes into three groups, according to the maturity of the longest bond in the comparison: up to six months; from six months to two years; and more than two years.[21] The purpose of this categorization of the different slopes was to represent the short, medium (generally associated with the monetary policy horizon), and long runs.

Table 7 presents the average change (across events) in the grouped tranches of the yield curve for each of the categories described, and the number of events in each group.[22] While there is a significant dispersion within each group, it appears that policies of asset purchases and term loan and liquidity facilities generated a reduction of between 10 and 20 basis points in the medium part of the yield curve, while generating increases in the slope at short horizons. On the other hand, measures expanding the list of eligible collateral seem to have had an insignificant impact during the first week after the announcement. In addition, the creation of swap lines with other central banks appears to have increased the slope at terms between six months and two years, while also increasing the shorter part of the curve after two weeks. Finally, the two cases in our sample of central banks paying interest on reserves were followed by decreases in the slope at short terms. Overall, it seems that the effects on the longer part of the curve have been minor, on average.

While the results reported in table 7 are a good first approximation to the data, they pool observations for different periods in a sample that has been characterized by different levels of financial volatility. In an attempt to control for the different phases in the observed

19. The data are the average monthly rate, and for some of the more recent dates we are missing observations.

20. A list describing each of the announcements included can be found in the appendix.

21. Unfortunately, the same maturity structure is not available for all countries, which forced us to make this grouping to compare the results.

22. A missing value in the table implies that for the country that has implemented the particular policy we do not have data on bonds within that particular maturity in the yield curve.

Table 7. Effects of Policies in the Yield Curve and Lending-Deposit Spread[a]

Average across events, change in basis points

Measure type	Number of obs.	Weeks after	Term structure: Up to 6 months	Term structure: 6 months to 2 years	Term structure: Over 2 years	Lending-deposit spread
Asset purchases and direct lending to financial firms	12	1	7	−19	−5	4
		2	3	−11	−5	
Expand list of collateral	10	1	1	−1	3	5
		2	39	2	1	
Interest on reserves	2	1	−4	6	20	
		2	−25	1		
Swap line with other central bank	6	1	−1	14	4	35
		2	22	17	3	
Term loan and liquidity facilities	26	1	15	−12	2	12.7
		2	25	−11	2	

Source: Authors' calculations.

a. For the term structure (columns 4−6), the table shows the average across observations of the change in the slopes between the observation one week before the announcement of the policy and either one or two weeks after, in basis points. For the Lending-deposit spread (column 7), we used the change in the spread (in basis points) between its average one month before and one after the announcement.

implementation of unconventional policies, we split the observations into different time frames to see whether these observed comovements differ over time.

Table 8 reports the results for three different time frames: before September 2008; between September and December of 2008; and after January 2009.[23] In terms of asset purchases, the minor reduction in the slope for the first part of the curve observed in the full sample contrasts with quite an important rise characterizing the three events that occurred between September and December of 2008, but for the other nine events the impact on the short part of the curve was mildly negative.[24]

A similar pattern can be observed for policies that extend the list of eligible collateral. Before September 2008, these types of announcements were associated with reductions in the slope of the short part of the yield curve, while after that month this tranche of the slope increased after the press release. In terms of policies introducing term loans and liquidity facilities, it seems that the flattening of the yield curve was more evident when these measures were implemented between September and December 2008 than after that period.

Another potentially useful split of the sample is reported in table 9. Here we distinguish between policies that were implemented before or after the rate had reached its lower bound. While we can see that unconventional policies were mainly implemented before the central bank chose to drive the policy rate to a low value, some differences are still apparent. In terms of policies in the asset purchase group, it seems that those implemented after the lower bound was reached were associated with stronger flattening effects on the yield curve. On the other hand, the opposite seems to be the case for policies creating term loans and liquidity facilities.

Finally, table 7 shows that unconventional measures were followed by increases in the lending-deposit spread, on average. However, the different time frame breakdowns in tables 8 and 9 reveal some exceptions. In particular, asset purchases seem to have been associated with increases in the spread only between

23. We do not show the results for policies in the group "paying interest on reserves" because the two observations in our sample occurred in the same time frame (between September and December of 2008). The same is true for the categories missing in the next table.

24. These numbers are mainly driven by the Canadian government's announcement that it would purchase up to 25 billion dollars in National Housing Act mortgage-backed securities.

Table 8. Effects of Policies on Yield Curve and Lending-Deposit Spread: Different Time Frames

Average across events, change in basis points

Measure type	*Time frame*	*Number of obs.*	*Weeks after*	*Term structure*			*Lending-deposit spread*
				Up to 6 months	*6 months to 2 years*	*Over 2 years*	
Asset purchases and direct lending to financial firms	Before Sept-08	1	1	−6		4	−3
			2	−9		5	
	Sept-08 to Dec-08	3	1	115	−19	−2	28
			2	70	−11	0	
	After Jan-09	8	1	−2		−8	−5
			2	−1		−8	
Expand list of collateral	Before Sept-08	2	1	−9	1	−1	−43
			2	−13	2	0	
	Sept-08 to Dec-08	6	1	5	−6	4	25
			2	56	2	1	
	After Jan-09	2	1		3	2	3
			2		3	1	
Swap line with other central bank	Sept-08 to Dec-08	4	1	−1	−6	7	7
			2	22	3	5	
	After Jan-09	2	1		33	1	77
			2		32	1	
Term loan and liquidity facilities	Before Sept-08	1	1	15		6	61
			2	5		5	
	Sept-08 to Dec-08	19	1	22	−14	3	7
			2	42	−13	2	
	After Jan-09	6	1	1	−5	1	29
			2	0	−6	−1	

Source: Authors' calculations.

September and December 2008. Moreover, there appears to be a marked difference in the observed behavior of the spread, depending on whether the rate was at its lower bound or not. Additionally, the two announcements of expansions to the list of eligible collateral implemented before September 2008—both by the Bank of Canada—were apparently associated with reductions in this spread as well. Nevertheless, it is worth repeating that the frequency of the data on these spreads is probably not the most suitable to analyze the effects of these types of events.

Overall, it seems that announcements of asset purchases, direct lending, term loan and liquidity facilities produced a reduction in the slope of the yield curve over medium horizons. For other types of announcements the evidence is less clear. These effects seem to have been more marked between September and December 2008 for both of the aforementioned categories. On the other hand, while the reduction in the slope generated by asset purchases and direct lending was apparently stronger after the policy rate reached the lower bound, the impact of term loan and liquidity facilities was stronger before reaching the lower bound. In contrast, the effect of both types of policies on the lending-deposit spread was more pronounced after the lower bound was reached.

3. Conclusions

Motivated by the numerous unconventional monetary policies that have been implemented during the current crisis, a new wave of research in monetary policy has emerged to analyze the scope and desirability of this heterodox behavior among central banks. The discussion is far from being settled and will probably keep both theorists and applied economists busy for years to come.

In this context, the goals of this paper were twofold. On one hand, we provided a theoretical analysis of the mechanisms relevant to understanding the effects of these unconventional policies that can be used as a framework for an ex post evaluation of the measures that have been implemented. In particular, we first discussed the role of credibility in implementing inflationary goals once the nominal interest rate reaches its lower bound, paying particular attention to the importance of the central bank's balance sheet. In addition, we presented a model that has at its core a financial imperfection that highlights the role of bank capital and the relevance of alternative credit policies that can be used to deal with financial distress.

Table 9. Effects of Policies on Yield Curve and Lending-Deposit Spread: Different Time Frames

Average across events, change in basis points

				Term structure			
Measure type	*MPR bound*	*Number of obs.*	*Weeks after*	*Up to 6 months*	*6 months to 2 years*	*Over 2 years*	*Lending-deposit spread*
Asset purchases and direct lending to financial firms	Before	4	1	-6		0	36
			2	-6		2	
	After	8	1	11	-19	-9	-14
			2	7	-11	-9	
Expand list of collateral	Before	9	1	1	-1	3	5
			2	39	2	1	
	After	1	1		3	0	
			2		3	-1	
Term loan and liquidity facilities	Before	22	1	21	-14	3	14
			2	36	-14	2	
	After	4	1	1	7	0	-3
			2	0	6	-2	

Source: Authors' calculations.

We also reviewed evidence regarding the recent experience of central banks that implement inflation-targeting regimes. We first described the timing and the type of unconventional policies that have been implemented. Second, we explored several alternative measures to assess the expansivity of monetary policy in a situation where the policy rate has reached its lower bound. Finally, we presented some descriptive evidence on the effect that the implemented policies have had on the shape of the yield curve and the lending-deposit spread, two variables that are relevant for the propagation of monetary policy.

Appendix

Notes on Data Sources and Available Sample Periods

Monetary policy rates: Central bank websites and Bloomberg; daily observations from January 2007 to September 2009. Monthly and quarterly averages were used in calculations.

Interest rates and yields: The International Monetary Fund's *International Financial Statistics* (IFS), Bloomberg and Central bank websites. Lending and borrowing rates correspond to monthly average rates. Yields correspond to daily nominal government bonds (Bloomberg query "GGR").

GDP, CPI, and industrial production:[25] The source of this data is the IFS. All series are seasonally adjusted. Consumer price index inflation corresponds to the quarterly annual percentage change. The GDP gap is computed as the percentage deviation from the Hodrick-Prescott trend. The price of oil employed corresponds to the West Texas Intermediate price in current U.S. dollars. The real and nominal exchange rates are from the IFS. Commodity prices correspond to the Commodity Research Bureau/Reuters U.S. spot price for all commodities.

25. For Australia, New Zealand, and Switzerland we used quarterly data for estimation purposes. The quarterly data set starts in 1980 Q1 for Australia, Canada, Denmark, Japan, Mexico, Norway, South Korea, Sweden, Switzerland, the United Kingdom, and the United States. For Brazil the data set starts in 1996 Q4, for Chile 1996 Q1, for Colombia 1994 Q1, for the Czech Republic 1993 Q1, for the euro area 1999 Q1, for Hungary 1985 Q1, and for Peru 1995 Q4. For all the countries in our sample the data set ends in 2009 Q1, except for Colombia whose data set ends in 2008 Q4. For monthly estimations, data sets start in January 1980 for Brazil, Canada, Denmark, Japan, Norway, South Korea, the United Kingdom, and the United States. For Switzerland, the data set starts in January 1995 and finishes in December 2007, for Chile the data set starts in July 1987, for Mexico in May 1981, for South Africa in December 1989, for the Czech Republic in January 1993, for Colombia in March 1995, for Peru in October 1995, for the euro area in January 1999, and for Hungary in October 1999. All the data sets end between May 2009 and August 2009, except for Switzerland whose data set finishes in December 2007.

Table A1. Timeline of Policy Announcements

Country	*Date*	*Measure*	*Type*
Australia	24-Sep-08	Domestic term deposit facility.	Term loan and/or liquidity facilities
	29-Sep-08	Swap facility with U.S. Federal Reserve.	Swap line with other central bank
	8-Oct-08	Expansion of domestic market facilities.	Term loan and/or liquidity facilities
	6-Nov-08	Domestic market dealing arrangements.	Term loan and/or liquidity facilities
	4-Feb-09	Reserve Bank of Australia and U.S. Federal Reserve swap facility.	Swap line with other central bank
	2-Mar-09	Domestic market dealing arrangements.	Term loan and/or liquidity facilities
Canada	15-Aug-07	Temporarily expands list of collateral eligible for SPRA transactions.	Expand list of collaterals
	31-Mar-08	Accepting asset-backed commercial paper (ABCP) as collateral for the Bank of Canada's standing liquidity facility.	Expand list of collaterals
	10-Oct-08	The federal government announced that it would purchase up to $25 billion in National Housing Act mortgage-backed securities.	Asset purchase and/or direct lending to financial firms
Chile	29-Sep-08	Reserve accumulation program was terminated, U.S. dollar 1-month repo operations announced (sales of U.S. dollar spot and purchases of 1-month U.S. dollar forward contracts through competitive auctions).	Term loan and/or liquidity facilities
	10-Oct-08	Broadening of eligible collateral for money market operations to include CDs; U.S. dollar repo program extended to six months.	Expand list of collaterals
	10-Dec-08	Extension of liquidity measures for all of 2009.	Term loan and/or liquidity facilities
		Enhancement of liquidity facility through credit lines accepting a broader range of collateral for longer tenors.	Expand list of collaterals
	9-Jul-09	Monetary policy rate at lower bound, short-term liquidity facility, suspension of debt emission of long maturities.	Term loan and/or liquidity facilities

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
Euro zone	26-Sep-08	Measures designed to address elevated pressures in the short-term U.S. dollar funding markets.	Term loan and/or liquidity facilities
	29-Sep-08	Conduct of a special term refinancing operation.	Term loan and/or liquidity facilities
	7-Oct-08	U.S. dollar liquidity-providing operations.	Term loan and/or liquidity facilities
	18-Dec-08	Tender procedures and the standing facilities corridor.	Term loan and/or liquidity facilities
	6-Apr-09	Eurosystem central banks announce expanded swap arrangements.	Swap line with other central bank
	7-May-09	Longer-term refinancing operations. ECB decides to enhance its set of non-standard measures.	Term loan and/or liquidity facilities
	4-Jun-09	Covered bonds purchase for 60 billion euro.	Other
	8-Jul-09	The European Investment Bank is made an eligible counterparty.	Expand list of collaterals
Japan	14-Oct-08	Increase in the frequency and size of repo operations. Steps to facilitate corporate financing.	Other
	31-Oct-08	Introduction of lending facilities.	Term loan and/or liquidity facilities
New Zealand	12-Oct-08	Deposit guarantee scheme introduced.	Other
	29-Oct-08	Reserve Bank of New Zealand (RBNZ) and Federal Reserve announce U.S. dollar facility.	Term loan and/or liquidity facilities
	7-Nov-08	RBNZ announces new facilities.	Term loan and/or liquidity facilities
	12-Dec-08	RBNZ announces further liquidity measures.	Term loan and/or liquidity facilities
	13-Jan-09	Tuesday OMO to accept corporate and asset-backed securities.	Expand list of collaterals
Norway	24-Sep-08	Central banks announce expanded swap facilities with U.S. Federal Reserve.	Swap line with other central bank
	12-Oct-08	Two-year F-loan for small banks.	Term loan and/or liquidity facilities
	29-Oct-08	Easing collateral requirements.	Expand list of collaterals

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
South Korea	27-Oct-08	Increase of aggregate credit; remuneration of reserves.	Interest on reserves
	8-Nov-08	Broadening eligible collaterals for open market operations (OMOs).	Expand list of collaterals
		Liquidity provisions to financial institutions.	Term loan and/or liquidity facilities
Sweden	22-Sep-08	Changed collateral requirements for credit in the Riksbank's funds transfer system (RIX).	Expand list of collaterals
	24-Sep-08	Central banks announce swap facilities with U.S. Federal Reserve.	Swap line with other central bank
	29-Sep-08	Riksbank announces new swap facility in U.S. dollars.	Term loan and/or liquidity facilities
	2-Oct-08	Riksbank lends 60 billion krona over three months.	Term loan and/or liquidity facilities
	6-Oct-08	Increased loans and longer maturity.	Term loan and/or liquidity facilities
	8-Oct-08	Changed collateral requirement for credit in RIX.	Expand list of collaterals
Switzerland	26-Sep-08	Measures taken by central banks to calm the money markets. 30 billion U.S. dollar swap line with the Federal Reserve to provide dollars in Swiss market.	Swap line with other central bank
	29-Sep-08	Swap line with the Federal Reserve increased to 60 billion U.S. dollars and extended to April 2009.	Swap line with other central bank
	15-Oct-08	Swiss National Bank (SNB) and ECB cooperate to provide Swiss franc liquidity.	Term loan and/or liquidity facilities
	16-Oct-08	Steps to strengthen the Swiss financial system. SNB finances transfers of UBS's illiquid assets.	Asset purchase and/or direct lending to financial firms
	18-Dec-08	SNB stab fund acquires first tranche of assets from UBS.	Asset purchase and/or direct lending to financial firms
	25-Jun-09	SNB continues to provide Swiss francs through euro-franc foreign exchange swaps.	Term loan and/or liquidity facilities

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
United Kingdom	19-Jan-09	Bank of England (BoE) announces 50 billion pound purchase of high-quality private sector assets.	Asset purchase and/or direct lending to financial firms
	9-Apr-09	BoE reduces bank rate to 0.5 percent and continues asset purchase facility with 75 billion pounds.	Asset purchase and/or direct lending to financial firms
	7-May-09	BoE maintains bank rate at 0.5 percent and increases size of asset purchase program by 50 billion pounds to 125 billion pounds.	Asset purchase and/or direct lending to financial firms
	4-Jun-09	BoE maintains bank rate at 0.5 percent and continues with 125 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms
	8-Jun-09	Asset purchase to be expanded to include secured commercial papers.	Asset purchase and/or direct lending to financial firms
	9-Jul-09	BoE maintains bank rate at 0.5 percent and continues with 125 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms
	6-Aug-09	BoE maintains bank rate at 0.5 percent and increases size of asset purchase program by 50 billion pounds to 175 billion pounds.	Asset purchase and/or direct lending to financial firms
	10-Sep-09	BoE maintains bank rate at 0.5 percent and continues with 175 billion pound asset purchase program.	Asset purchase and/or direct lending to financial firms

Table A1. (continued)

Country	*Date*	*Measure*	*Type*
United States	21-Dec-07	Federal Reserve intends to continue term-auction facilities (TAFs) as necessary.	Term loan and/or liquidity facilities
	13-Jul-08	Lending to Fannie Mae and Freddie Mac at the primary credit rate is authorized.	Asset purchase and/or direct lending to financial firms
	19-Sep-08	Asset-backed commercial paper money market fund liquidity facility (AMFL) or "the facility" established.	Term loan and/or liquidity facilities
	6-Oct-08	Fed will begin to pay interest on depository institutions' required and excess reserve balances and increase the TAF.	Interest on reserves
	2-Dec-08	Extension of three liquidity facilities through 30 April 2009: the primary dealer credit facility (PDCF), the AMLF, and the term securities lending facility (TSLF)	Term loan and/or liquidity facilities
	10-Feb-09	Federal Reserve expands term asset-backed securities loan facility (TALF) and accepts wider set of collateral; announces willingness to expand TALF to 1 trillion U.S. dollars.	Term loan and/or liquidity facilities
	18-Mar-09	Fed increases balance sheet by purchasing a further 750 billion dollars of asset-backed securities from agencies, bringing the year's total purchases up to 1.25 trillion dollars. Announcement of program to buy 300 billion dollars worth of Treasury securities.	Asset purchase and/or direct lending to financial firms
	25-Jun-09	Extension of liquidity facilities and swap lines.	Term loan and/or liquidity facilities

Source: National central banks.

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