Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 601

Diciembre 2010

PRICE LEVEL TARGETING AND INFLATION TARGETING: A REVIEW

Sofía Bauducco   Rodrigo Caputo

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Agustinas 1180, Santiago, Chile
Teléfono: (56-2) 3882475; Fax: (56-2) 3882231

Documento de Trabajo
N° 601

Working Paper
N° 601

PRICE LEVEL TARGETING AND INFLATION TARGETING: A REVIEW

Sofía Bauducco
Gerencia de Investigación Económica
Banco Central de Chile

Rodrigo Caputo
Gerencia de Investigación Económica
Banco Central de Chile

Abstract

In this paper we discuss the arguments for and against the adoption of price-level targeting. We review recent theoretical contributions, and illustrate the main differences between price-level targeting and inflation targeting in a simple New Keynesian model. We conclude that, contrary to conventional wisdom, price-level targeting can, in some circumstances, deliver better outcomes than inflation targeting. Its main advantage lies on the fact that it acts as a commitment device when the Central Bank is unable to commit to its future actions. However, even in the circumstances under which price-level targeting performs better, there are three caveats to be considered. First, a higher proportion of backward-looking price setters reduces the effectiveness of price-level targeting, because it weakens the expectational channel through which price-level targeting operates. Second, communicating a price-level target may be a difficult task for the Central Bank. Finally, price-level targeting itself is not immune to considerations of time-inconsistency.

Resumen

En este trabajo discutimos los argumentos a favor y en contra de la adopción de un esquema de política monetaria de metas de nivel de precios. Revisamos las contribuciones teóricas recientes, e ilustramos las principales diferencias entre esquemas de metas de nivel de precios y metas de inflación en un modelo neo-keynesiano simple. Concluimos que, contrariamente a la creencia convencional, un esquema de metas de nivel de precios puede, en algunas circunstancias, arrojar mejores resultados que un esquema de metas de inflación. Su principal ventaja reside en el hecho de que este esquema actúa como un mecanismo de compromiso cuando el Banco Central no puede comprometerse a acciones futuras. Sin embargo, incluso en las circunstancias en las que el esquema de metas de nivel de precios se desempeña mejor, existen tres desventajas a tener en cuenta. En primer lugar, una proporción alta de agentes que fijan precios teniendo en cuenta información pasada reduce la efectividad del esquema de metas de nivel de precios, ya que debilita el mecanismo de expectativas bajo el cual opera el esquema. En segundo lugar, comunicar una meta para el nivel de precios puede ser difícil para el Banco Central. Finalmente, un esquema de metas de nivel de precios no es inmune a consideraciones de inconsistencia temporal.

We would like to thank Luis Felipe Céspedes, Sebastián Claro, José Dorich, Pablo García, Javier García-Cicco, José de Gregorio, Manuel Marfán, Enrique Marshall, Bruce Preston, Rodrigo Vergara and an anonymous referee for useful discussion while preparing this document. The opinions expressed in this paper are sole responsibility of the authors and by no means represent the views of the Central Bank of Chile. All remaining errors are our own. sbauducco@bcentral.cl, rcaputo@bcentral.cl.

1 Introduction

Monetary authorities in developed and developing economies have, as one of their main objectives, to achieve price stability. In order to achieve this goal, many central banks formally use inflation targeting (IT) as their policy framework [1]. As noted by Ambler (2009) until the onset of the current worldwide recession, inflation and output fluctuations have been less volatile in IT countries. Furthermore, as suggested by Carlstrom et al. (2009), one of the elements behind the sharp decline in inflation persistence in the USA has been a more aggressive policy reaction towards inflation.

Besides being the monetary framework adopted by many central banks in practice, in theory IT can implement the efficient allocation in a closed economy as discussed by Clarida et al. (1999). In particular, the optimal policy calls for gradual adjustment of the policy rate in order to bring inflation to its target (optimal) level. This policy prescription also applies to a small open economy (Gali and Monacelli (2005)).

An alternative policy regime, that also ensures long run inflation stability, is price level targeting (PT). Under this framework, the central bank acts to return the price level to its original targeted growth path.

In recent years there has been some discussion about the advantages of PT over IT. In particular, the conventional wisdom that sees PT as a regime that stabilizes the price level in the long run, but induces more short-term volatility in inflation and output has been challenged. On the one hand, various theoretical contributions have pointed out at the advantages of PT over IT under different circumstances[2]. On the other hand, the Bank of Canada is considering PT as an alternative framework to be adopted in 2012 when the contract with the government is renewed. In this context, several studies have investigated the advantages and costs of adopting PT in the Canadian economy. Finally, some central bankers, notably Lars Svensson from the Swedish Central Bank and Charles Evans from the FED, have argued that a transitory move to PT can induce expectations of positive inflation. In a context in which the zero lower bound has been reached, this mechanism reduces the real ex ante real interest rate and therefore stimulates the economy.

The objective of this document is twofold. First, we discuss the arguments in favor and against the adoption of PT. In doing so, we review recent theoretical contributions, as well as the research agendas undertaken in Central Banks (notably the Bank of Canada), assessing the benefits and cost of PT. Second, we illustrate the main differences between PT and IT in a modified version of Vestin (2006) New Keynesian model. In the exercise we undertake, we show how the expectation channel is key in determining how PT under discretion can perform better

[1] Currently 26 countries have adopted this policy regime (Lim (2009)).

[2] See Svensson (1999), Vestin (2006) and Preston (2008), among others.

than IT under discretion.

We conclude that, contrary to the conventional wisdom, PT can be in some circumstances a more convenient alternative than IT. Its main advantage lies on the fact that PT acts as a commitment device when the central bank is unable to commit to its futures actions. When commitment is possible, however, IT can, in general, implement the optimal allocation. As an extension to the current literature, Preston (2008) shows that PT may have a better performance in an environment that departs from rational expectations, even if commitment is possible. In particular, if agents do not have rational expectations and learn adaptively, the optimal policy might best be implemented by explicit reference to the path of the price level rather than the inflation rate.

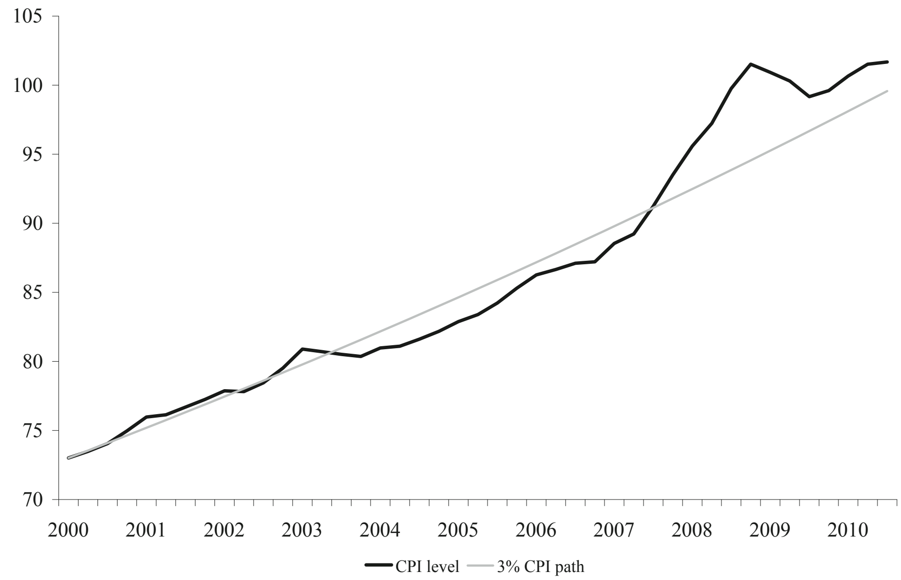
Now, even in the circumstances under which PT performs better than IT, there are some caveats to be considered. First, the strength of PT comes from the possibility to affect private agents' expectations. Therefore, in models in which producers set prices according to past values of relevant variables such as inflation, price level targeting is less effective. In the limit, if all producers are backward-looking, PT is ineffective. Second, another problem with PT arises from its implementation. Communicating a target in terms of the aggregate price level is a complicated task, and it may require a considerable length of time before the private sector correctly forms expectations about the evolution of inflation and the output gap from the announcement that monetary policy will seek to stabilize prices around a particular trend. Finally, PT arises as an interesting alternative when there is lack of commitment from the monetary authority to future policies. However, PT itself is not immune to considerations of time-inconsistency.

This document is organized as follows. In Section 2 we present the main arguments behind the recent discussion about the advantages (and costs) of PT. In Section 3 we present a simple rational expectations model with sticky prices that can be used to analyze the relative performance of PT and IT in the face of a cost push shock. In Section 4, we present numerical examples that shed light on the main mechanisms that are present in this simple model. Section 5 discusses some extensions. In particular, we analyze the implications of introducing additional rigidities and the consequences of assuming that agents do not have rational expectations. Section 6 discusses, more generally, the main advantages and costs of PT versus IT. Finally, Section 7 concludes.

2 IT versus PT: moving away from conventional wisdom

As mentioned before, price stability, normally intended as low and stable inflation, is the primary stated goal of monetary policy for many central banks around the world. Under IT, the central bank is trying to stabilize the inflation rate around some target value. Such policy implies that the price level can drift arbitrarily far away from any predetermined time trend, but inflation

Figure 1: Consumer Price Index (CPI) in Chile



will eventually converge to its target level. In this case, transitory supply shocks may shift the level of prices in a permanent way. As a consequence, as the forecast horizon increases, the forecast-error variance for the price level increases.

An alternative policy, PT, stabilizes the price level around a deterministic trend. In this case, the central bank acts to return the price level to its original targeted growth path. In this case, a transitory shock to the price level, causing temporary above-average inflation, must be followed by a correction implying below-average inflation, and vice-versa. Eventually, under both regimes inflation can be stabilized in the long run, but only PT ensures that the price level will be stabilized around a target level. Under IT the level of prices does not necessarily converge to a given path. An illustration of this is given in Figure 1, showing the evolution of CPI in an IT country, Chile. As is clear from the figure, the price level is not anchored to a given path, although the inflation rate is converging to 3%.

As noted by Gaspar et al. (2007), the conventional wisdom in central banking circles is that price level path stability is not an appropriate goal to delegate to an independent central bank [3]. The intuition behind this claim is that, under a regime of price level path stability, a shock to the price level, causing temporary above-average inflation, must be followed by a correction

[3] See Fischer (1994); Fillion and Tetlow (1994); Lebow et al. (1992) and Haldane and Salmon (1995).

implying below-average inflation, and vice-versa. The use of monetary policy to move around inflation, in order to stabilize the price level, implies an increase in the short-run volatility of inflation. Furthermore, if prices are sticky, moving around inflation requires pushing output above or below its potential level. Therefore, PT would induce more short-term volatility in both inflation and the output gap. Hence, the traditional view is that PT induces a trade-off between the longer-run benefits of increased price-level predictability and the short-run costs of increased variability of both prices and output.

In recent years, however, this conventional wisdom has been challenged for two reasons. First, in recent academic contributions Svensson (1999) and Vestin (2006) have demonstrated that in some circumstances PT can be a better alternative than IT. In particular, when the central bank lacks commitment to future policies, implementing PT even under discretion (i.e. reoptimizing in each period) comes close to the the first best allocation. In this case, a shock that deviates prices from target is going to induce the policymaker to try to stabilize prices in every period. This leads to lower expected inflation. Private agents will incorporate this into their price setting decisions, inducing a lower level of contemporaneous inflation. Hence, in the face of supply shocks, the expectation channel under PT contributes to stabilize inflation. This reduces the required contraction in output and, therefore, it improves the policy trade-off. Hence, contrary to the conventional wisdom, PT is able, in theory, to implement an equilibrium similar to the one in IT under commitment. In this sense, PT acts as a commitment device when central banks are unable to commit to future actions.

Second, in the policy arena, the Bank of Canada is considering PT as one of the options when renewing its contract with the government in 2011. This has generated an important research agenda at the Bank of Canada, assessing the advantages and costs of implementing PT. For instance, Kryvtsov et al. (2008) measure the welfare gains of switching from IT to PT under imperfect credibility. They use a simple theoretical model (as in Vestin (2006)) in which there is a gradual adjustment of the private sector's beliefs about the policy change. They find that gains from switching to PT are positive, but small. Subsequently, Cateau et al. (2009) use the DSGE model of the Canadian economy, ToTEM, to study the impact of switching to PT in a similar imperfect credibility environment. They find that, even if the policy change is not completely credible, there are significant gains from adopting PT. In this case, PT works as an automatic stabilizer that works via the effect of expected inflation on current inflation. This mechanism is absent from the IT solution. Covas and Zhang (2008), compare the performance of PT and IT in a model estimated for the Canadian economy. In particular, they consider a sticky-price, dynamic, general equilibrium model augmented with imperfections in both the debt and equity markets. They find that, in general, PT outperforms the current IT regime. Again, in this case the inflation expectation channel which is present in the case of PT is explaining its better performance.

In summary, the traditional view sees PT as inducing a trade-off between the longer-run benefits of increased price-level predictability and the short-run costs of increased variability of both prices and output. The contribution of the recent literature has been to show that, under certain conditions, PT can actually lead to an improved trade-off between inflation and output variability. In particular, if the Central Bank is unable to commit to future actions (i.e. operates under discretion) PT can approximate the commitment solution, because it can stabilize future inflation expectations. To see how this mechanisms works, in the next two sections, we present the results of simulating the dynamic responses of the economy to a supply shock, under both PT and IT in a simple New Keynesian model.

3 The Model

In order to clarify the concepts previously discussed, we present a model based on Vestin (2006), which is a simple version of a standard new keynesian model of the type discussed at length in Gali (2008).

The supply side of the economy is described by the Phillips curve, which relates current inflation with expectations of future inflation and current output gap:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t \tag{1}$$

where all variables are expressed as log-deviations from its steady state values. π_t refers to inflation in period t, x_t denotes the output gap and u_t is a cost-push shock that follows the process:

$$u_t = \rho u_{t-1} + \epsilon_t$$

As explained in Gali (2008), the Phillips curve depicts the pricing decisions taken by monopolistically competitive producers that adjust prices with an exogenous probability $1 - \theta$. κ is a parameter that depends on the degree of price stickiness θ, the intertemporal discount factor of households β, the coefficient of relative risk aversion σ, the inverse of the Frisch elasticity φ and on the measure of decreasing returns to scale in the production function α[4].

In the Phillips curve, if prices are completely sticky (i.e $\theta = 1$), then $\kappa = 0$. In this case, changes in marginal costs do not have an impact on inflation, given that agents can never reoptimize prices. On the contrary, if prices are fully flexible (i.e. $\theta = 0$) then κ tends to infinity. In this case, the Phillips curve is vertical.

The household's optimality conditions state that the allocation of consumption across time depends on the real ex-ante interest rate. These conditions are summarized by means of the IS

[4]For a detailed derivation of this equation, see Gali (2008).

curve:

$$x_t = E_t x_{t+1} - \gamma(i_t - E_t \pi_{t+1}) \tag{2}$$

where i_t is the nominal interest rate. Notice that this equation relates the nominal interest rate, which is the instrument that the Central Bank uses in order to stabilize the economy, to the current output gap, given expectations about inflation and the future output gap. We simplify the analysis by assuming that the Central Bank can directly manipulate the output gap and, consequently, we can omit equation (2).

Society's period by period loss function is of the form:

$$L_t = \frac{1}{2}(\pi_t^2 + \lambda x_t^2) \tag{3}$$

This equation can be derived from a second-order approximation to the utility function of households, plugging in the appropriate optimality conditions of households and firms. Notice that the cost-push shock introduces a trade-off in the decision problem of the policy maker: it is not possible to fully stabilize x_t and π_t at the same time. Were u_t absent from the Phillips curve, the Central Bank would be able to fully stabilize inflation by stabilizing the output gap every period. However, if $u_t \neq 0$ this will no longer be possible, and the policy maker will have to choose the sequences $\{\pi_t, x_t\}$ that minimize society's intertemporal loss function.

3.1 The Central Bank and the delegation problem

We assume that there is a benevolent planner that indicates to the Central Bank which loss function it should minimize when setting its policy. We are assuming, in a sense, that society delegates the problem of how to handle monetary policy to an independent Central Bank, provided that it minimizes a given loss function.

Following Vestin (2006), we consider three scenarios under which the Central Bank sets monetary policy. First, we describe the problem faced by the Central Bank when it can credibly commit to its announced policy. In this case, the loss function it minimizes corresponds to society's loss function. This constitutes the first best solution, and provides the benchmark case to which we compare the remaining outcomes[5]. The second scenario we consider is one in which the Central Bank cannot commit to future policies, and seeks to minimize (log) deviations of the output gap and inflation from their steady state values. This scenario correspond to IT under

[5] As in Vestin (2006), we follow the timeless perspective approach to compute the commitment solution. Dennis (2010) points out to the fact that, in some cases, the timeless perspective solution may be dominated by the discretion solution. However, since in our analysis we evaluate policies at their asymptotic equilibrium and are not concerned about transition dynamics, the timeless perspective policy and the optimal commitment policy coincide and we can conclude that the discretion solution can never dominate the commitment one.

discretion. Finally, we consider the case in which, as before, the Central Bank cannot commit to future policies, but now seeks to minimize deviations of the output gap and the *price level* from their steady state counterparts. In this case, the Central Bank is pursuing PT under discretion.

3.1.1 The First Best Equilibrium: Inflation Targeting under Commitment

Under commitment, the Central Bank has to choose a sequence $\{x_{t+j}, \pi_{t+j}\}_{j=0}^{\infty}$ such that society's intertemporal loss function is minimized. More precisely, the problem of the Central Bank is:

$$\min_{\{x_{t+j},\pi_{t+j}\}_{j=0}^{\infty}} E_t \sum_{j=0}^{\infty} \frac{\beta^j}{2} (\pi_{t+j}^2 + \lambda x_{t+j}^2)$$

subject to the Phillips curve (1). The Lagrangian of the problem can be written as:

$$\mathcal{L} = E_t \sum_{j=0}^{\infty} \frac{\beta^j}{2} \left[(\pi_{t+j}^2 + \lambda x_{t+j}^2) + \phi_{t+j}(\pi_{t+j} - \kappa x_{t+j} - \beta \pi_{t+j+1} - u_{t+j}) \right]$$

It can be shown that the solution to this problem is of the form:

$$x_t = -cp_{t-1} - du_t \tag{4}$$

$$p_t = ap_{t-1} + bu_t \tag{5}$$

where a, b, c and d depend on the parameters of the model, and p_t is the price level in period t. In particular, it is the case that

$$\lim_{\lambda \to 0} a^*(\lambda) = 0$$

$$\lim_{\lambda \to \infty} a^*(\lambda) = 1$$

The previous results imply that the response of prices to shocks will be determined by λ, which is the weight assigned to the output gap in the loss function. As λ goes to zero, society cares relatively less about the output gap and, consequently, prices adjust fully to offset the effect of the shocks on inflation. In this case the Central Bank does full inflation targeting. On the contrary, when λ goes to infinity, society does not care about inflation. This translates into prices being highly persistent. It is easy to see, then, that the price level is stationary, except in the limiting case in which $\lambda \to \infty$.

3.1.2 Inflation Targeting under Discretion

When the Central Bank cannot commit to sustain future policies, it focuses on minimizing only the current period's loss function. This contrasts with the previous case, in which the fact that there was commitment implied that the Central Bank minimized the whole discounted sum of future loss functions. Because we are considering an inflation targeting regime, the loss function that the government delegates on the Central Bank has the same functional form as the true social loss function. However, now the weight on the output gap λ can be modified such that the solution under discretion comes as close as possible to minimizing the intertemporal social loss function. For this reason, we denote by $\hat{\lambda}$ the weight of the output gap in the delegated loss function.

The problem of the Central Bank can be written as

$$V(u_t) = E_t \left[\min_{x_t} \frac{1}{2}(\pi_t^2 + \hat{\lambda} x_t^2) + \beta V(u_{t+1}) \right]$$

s.t.

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t$$

In this case the solution is

$$x_t = -\hat{d} u_t \tag{6}$$

$$p_t = p_{t-1} + \hat{b} u_t \tag{7}$$

It is obvious from the last expressions that, in the case of discretion and inflation targeting, the price level is no longer stationary but, on the contrary, displays a unit root.

3.1.3 Price Level Targeting under Discretion

As in the previous case, we consider the situation in which the Central Bank cannot commit to future policies. However, in contrast with the previous scenario, we assume now that the loss function that the government delegates on the Central Bank implies minimizing deviations of the output gap and the price level from their steady state counterparts. Notice that it is still the case that society's welfare is maximized when deviations of inflation and the output gap are minimal. Nevertheless, the fact that there is no commitment on the part of the Central Bank implies that the inflation targeting solution may be too far from the first best solution. As we will argue in the next section, providing the Central Bank with a loss function with different arguments from the social loss function may deliver policies that are closer to the first best solution.

The problem that the Central Bank solves is

$$V(p_{t-1}, u_t) = E_t \left[\min_{x_t} \frac{1}{2}(p_t^2 + \tilde{\lambda} x_t^2) + \beta V(p_t, u_{t+1}) \right]$$

s.t.

$$p_t - p_{t-1} = \beta E_t(p_{t+1} - p_t) + \kappa x_t + u_t$$

It can be shown that the solution in this case is of the form[6]

$$x_t = -\tilde{c} p_{t-1} - \tilde{d} u_t \tag{8}$$

$$p_t = \tilde{a} p_{t-1} + \tilde{b} u_t \tag{9}$$

where

$$\lim_{\lambda \to 0} \tilde{a}(\tilde{\lambda}) = 0$$

$$\lim_{\lambda \to \infty} \tilde{a}(\tilde{\lambda}) = 1$$

Once again the price level follows a stationary process, except in the case in which the weight assigned to the output gap in the loss function goes to infinity. From this result, it is already evident that the optimal policy with discretion and price level targeting delivers a trajectory for the price level closer to the one arising from the commitment solution than the inflation targeting one.

4 Numerical examples

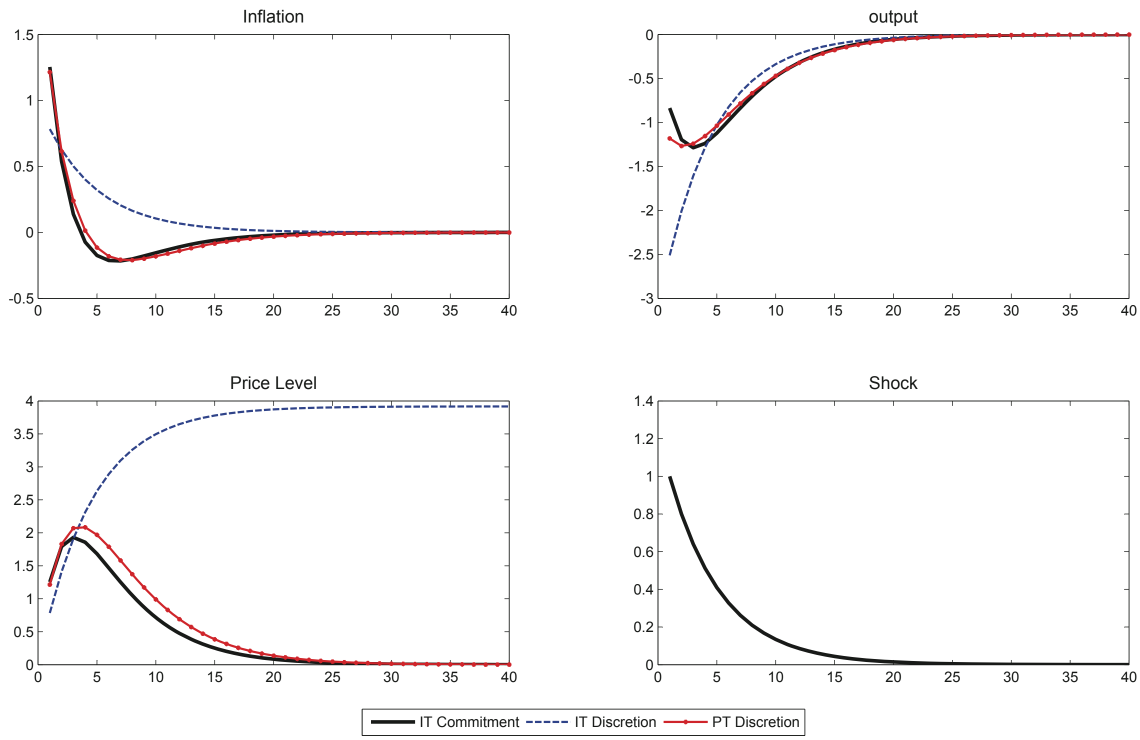
In order to shed light on the mechanisms behind the three results depicted above, we propose some numerical examples in which we compute the response of the Central Bank to a given cost-push shock, under the three scenarios of interest.

We consider a benchmark parameterization in which we set $\beta = 0.99$, $\rho = 0.8$ and $\kappa = \frac{1}{3}$. λ is assumed to be equal to 0.5. In the case of inflation targeting with discretion, it can be shown that $\hat{\lambda} = (1 - \beta\rho)\lambda$. Finally, when we consider price level targeting with discretion, we choose $\tilde{\lambda}$ such that[7]

[6] Notice that the solution to this problem is not trivial, since the decision variable of the planner is also a state variable for future planners, which is reflected in the fact that $V(\cdot)$ depends on p_{t-1}. The derivation of the solution to this problem can be found in the appendix of Vestin (2006). The interested reader can also check the paper by Soderlind (1999) for details on how to solve problems under discretion as the one depicted here.

[7] We make use of the fact that, when $\beta \to 1$, $\tilde{\lambda}$ can be found by minimizing the loss function $L = \text{var}(\pi_t) + \tilde{\lambda}\text{var}(x_t^2)$.

Figure 2: Impulse-response functions to a cost-push shock, $\rho = 0.8$



$$\underset{\tilde{\lambda}}{\text{argmin}}\ L = E_t \sum_{j=0}^{\infty} \frac{\beta^j}{2} (\pi_{t+j}^2(\tilde{\lambda}) + \lambda x_{t+j}^2(\tilde{\lambda})) \tag{10}$$

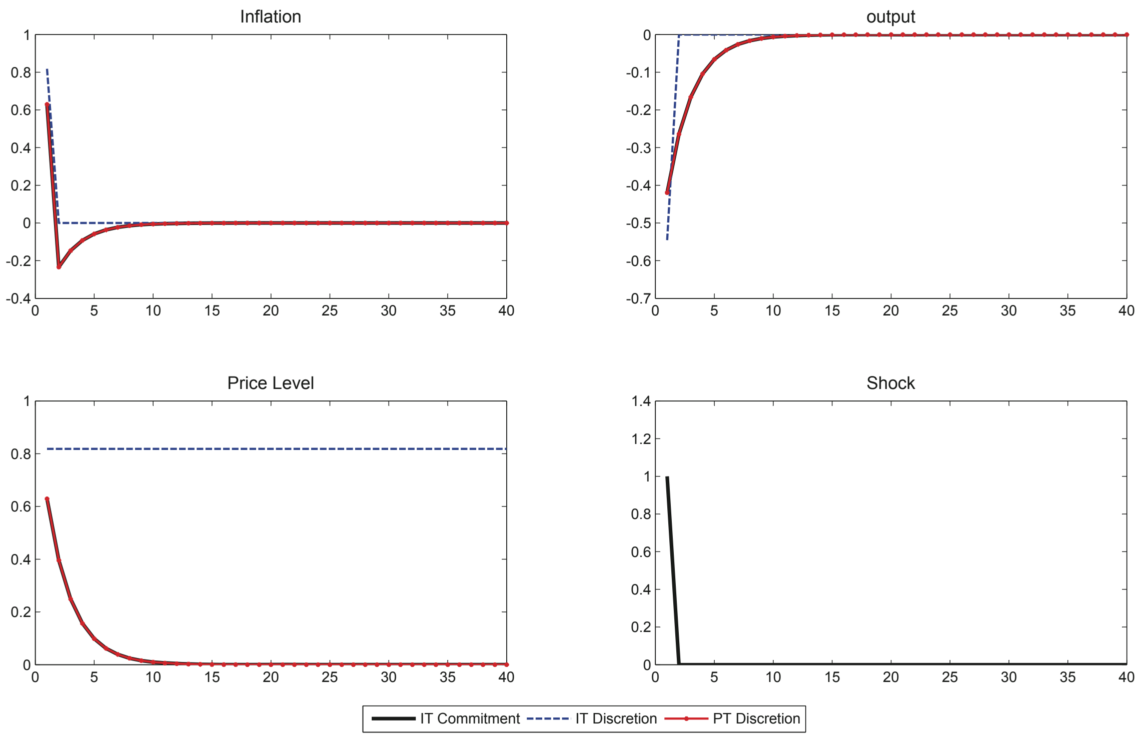
We solve the model[8][9] and simulate the path of the relevant variables in the economy for a one standard deviation cost-push shock. Figure (2) shows the impulse response functions of inflation, output and the price level under the three different policy regimes. It is clear from this figure that the price level targeting solution closely mimics the solution under commitment. Under inflation targeting and discretion, however, the variables display a very different path than in the two previous cases.

The differences in the responses of variables under price level targeting and inflation targeting, when the Central Bank cannot commit to future policies, are due to the expectational channel embedded in each case. When the Central Bank follows an inflation targeting regime, it only cares about stabilizing the current period's inflation rate and the output gap. This implies that, under a cost push shock, it will have to tolerate a negative output gap in order to damper

[8]The analytical representations of the solution are provided in Vestin (2006).

[9]Appendix A.1 contains the value of the policy functions' parameters for each case analyzed in this section.

Figure 3: Impulse-response functions to a cost-push shock, $\rho = 0$

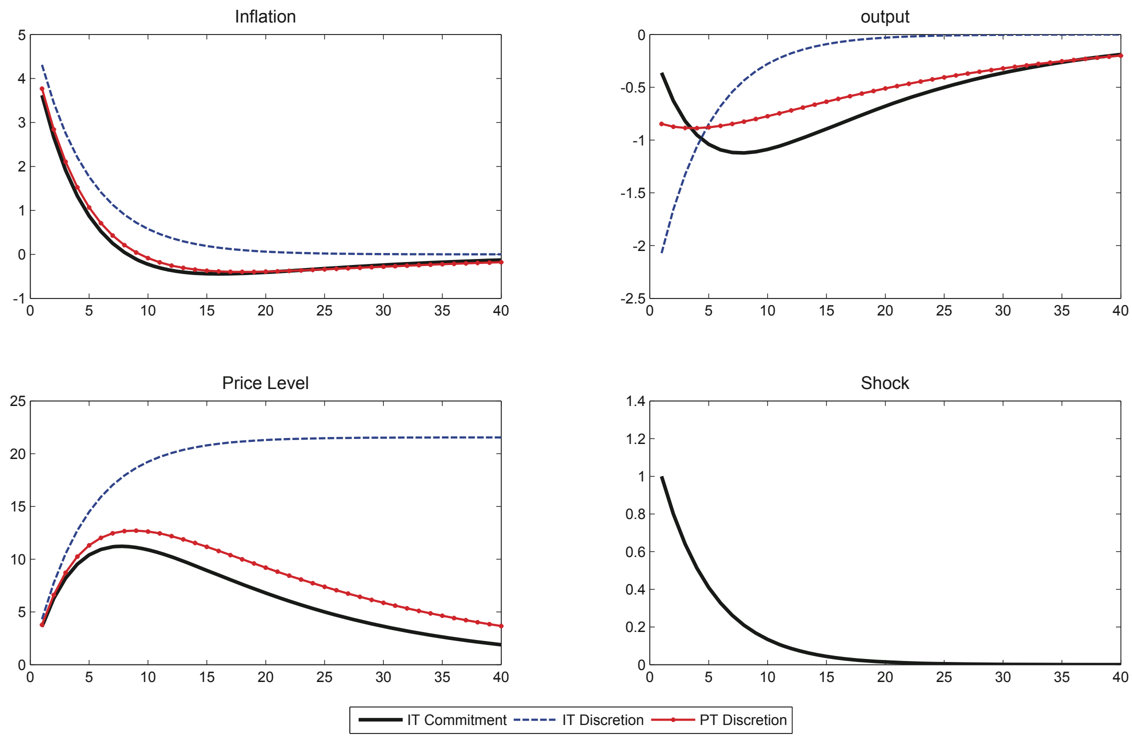


the effect of the shock over inflation. As the shock fades out in time, so does the response of inflation and output gap. In this case, the Central Bank cannot exploit the expectational channel, because it lacks commitment[10]. The price level never returns to its original level, as the monetary authority only cares about the growth rate of prices, but not about the price level itself.

By definition, in a price level targeting regime, agents in the economy expect that deviations of the price level today will be reverted in the future. Therefore, producers know that a cost-push shock today, which implies inflation this period, will translate into deflation in future periods, as the Central Bank will correct the initial increases in the price level by subsequent decreases. Given that prices are sticky, producers that can set their prices today will increase them less than in the inflation targeting case, because of the anticipated future deflation. The exploitation of this expectational channel, which is also present in the commitment scenario, allows the Central

[10]In this case, the Central Bank could make a promise that it will tolerate a deflation in the future. This could attenuate, via expected inflation, the current impact of the shock on both inflation and output. However, a Central Bank that optimizes period by period has the incentive to renege of this promise and avoid a deflation. If this is internalized by economic agents, the equilibrium under commitment is not sustained.

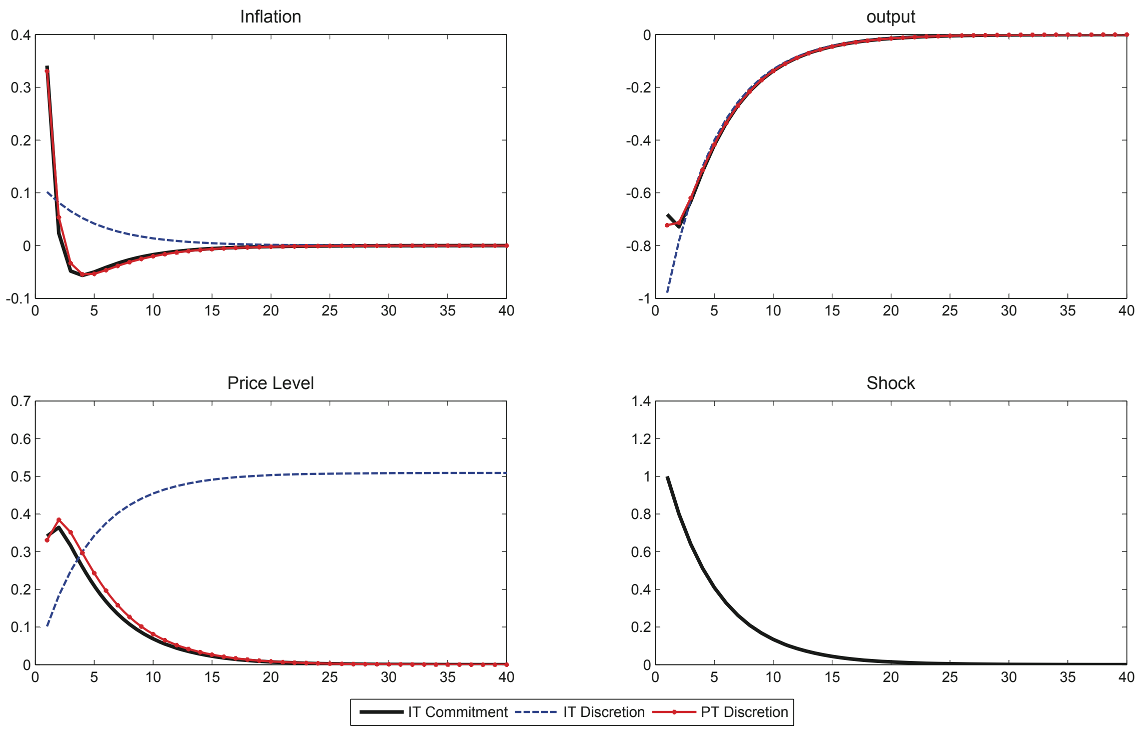
Figure 4: Impulse-response functions to a cost-push shock, $\rho = 0.8$, $\kappa = 0.05$



Bank to, in the presence of a cost-push shock, stabilize the economy by handling in a more efficient way the inflation-output gap trade-off.

Figure 3 shows the evolution of the variables in the economy in the case in which the cost-push shock is i.i.d. (i.e., $\rho = 0$). Although the main results are the same as in the previous case, there are some remarkable features in this example worth pointing out. First, in the special case in which $\rho = 0$, the price level targeting solution exactly replicates the commitment solution, so there is no welfare loss associated to the lack of commitment. Second, under inflation targeting and discretion, the response of the monetary authority to the shock lasts only for one period. This is the case because in this case the Central Bank responds only to current deviations of inflation. Therefore, the optimal response in this case is to let prices adjust during the period that the shock takes place and never revert the increase in the price level. On the contrary, in the cases of commitment and price level targeting, the response of the Central Bank prevails long after the shock has taken place. The reason for this is that the monetary authority has to gradually undo the initial increase in the price level by generating deflations. Again, because deflations are credible under PT and IT under commitment, the actual level of inflation is lower.

Figure 5: Impulse-response functions to a cost-push shock, $\rho = 0.8$, $\kappa = 1$



4.1 Sensitivity analysis

In this section we perform some robustness exercises to see whether the results previously depicted change when we vary some of the parameters of the simple model presented in the last sections.

Figure 4 shows the impulse response functions when we consider $\kappa = 0.05$, which corresponds to the case in which prices are more sticky. Price level targeting dominates the inflation targeting solution under discretion, and it implies a less abrupt response of the output gap to the shock. Once again, the difference in the response of variables between the cases of price level targeting and inflation targeting under discretion can be explained through the expectational channel that the Central Bank can exploit in the case of price level targeting. Given that prices are very sticky, and given that, with price level targeting, agents expect future lower levels of inflation (or even deflation) following the positive cost-push shock, the output gap need not respond so strongly to the shock.

Finally, Figure 5 corresponds to the case in which prices are very flexible, so $\kappa = 1$. We can observe that in this case, for the three scenarios considered, prices respond very mildly to the shock, and in the cases of commitment and price level targeting, the price level goes back to its initial level as soon as the shock dies out. It is still the case that price level targeting dominates inflation targeting when there is discretion.

4.2 Inflation targeting, price level targeting and the zero lower bound

After the financial crisis of 2008-2009, there has been an active debate on how to deal with situations in which the nominal interest rate hits its lower bound of zero and, consequently, the economy is in a liquidity trap. In this respect, price level targeting has received attention from the profession for two reasons. First, an economy that is in a price level targeting regime will hit the zero lower bound less frequently than an economy with an inflation targeting regime under discretion. Moreover, once in a liquidity trap, economies with price level targeting regimes can exit the trap more easily than economies under inflation targeting.

The reason behind these results is, once more, the expectational mechanism embedded in price level targeting. By this mechanism, during a deflation agents expect future inflations such that the price level returns to its target path. Consequently, even with a fixed nominal exchange rate, expected future inflation causes the real interest rate to decrease which, in turn, boosts output. Then, during a crisis as the one recently experienced, the decrease in the nominal interest rate needed to boost the economy is lower with price level targeting than with inflation targeting and, if a liquidity trap is reached, the price level targeting regime does the job of generating expectations of future inflations, without having to resort to unconventional measures. Hence, and as noted by various studies [11], the Central Bank is more effective at shaping private-sector expectations about future inflation by targeting directly the price level path rather than inflation.

On the other hand, Billi (2008) shows that simple price-level targeting rules provide an "insurance" against downside tail risk (such as hitting the zero lower bound in a low inflation economy). In this case, as before, price-level targeting may imply less variability of inflation than inflation targeting, since policymakers can shape private-sector expectations about future inflation more effectively by targeting directly the price level path rather than inflation.

5 Extensions

As shown before, PT outperforms IT when the central bank lacks commitment. This results holds in theory as well as in quantitative research that evaluates the relative performance of PT in medium scale macro models. However, if commitment is possible, IT is able to implement the first best allocation. This conclusion is derived in simple New Keynesian models, with rational expectations and sticky prices. In this section we review some the implications of PT in models

[11] See Coenen and Wieland (2004), Eggertsson and Woodford (2003), Gaspar et al. (2007), McCallum (2000), Nakov (2008), Svensson (2003) and Wolman (2005) among others

that go beyond the standard paradigm. In particular, we discuss the implications of considering additional nominal frictions and removing the assumption of rational expectations.

Givens (2009) considers a New Keynesian model with sticky prices and wages. The first best allocation can be implemented by targeting a linear combination of wage and goods inflation as well as the output gap [12]. In this setup, a central bank pursuing PT under discretion is unable to approximate the first best allocation. In particular, this type of policy induces more volatility in wage inflation, which has a negative impact on social welfare. A policy that targets, under discretion, a linear combination of goods prices and nominal wages (both in levels) has a better performance. In particular, a price and wage targeting regime (PWT), under discretion, is able to approximate well the first best allocation. This policy, however, is still marginally worse than the optimal one. In summary, in this setup goods-price targeting generates greater deadweight losses than inflation targeting. Conversely, assigning a nominal wage target yields outcomes that are superior to goods-price targeting and inflation targeting. The gains from targeting the price of labor can be traced to the importance of nominal wage inflation in the utility-based social loss function as well as the sensitivity of wages to output gap fluctuations via the Phillips curve. Overall, in this setup IT under commitment is still the optimal policy.

In a different contribution, Preston (2008), considers a model that removes the standard assumptions about rational expectations and common information on the part of private agents and the Central Bank. This implies that these economic actors do not necessarily hold common expectations about future macroeconomic conditions. In contrast to the IT rule, the PT criterion displays robustness to the model used by the Central Bank to construct projections. Even if the central bank mistakenly assumes agents to have rational expectations, the price-level targeting rule leads to stability under learning dynamics for many empirically reasonable parameter values.

According to Preston (2008), the difference between these two rules, in the case of learning dynamics, is that the PT rule specifies a different kind of subsequent behavior when one finds that (because the private sector does not behave as they were projected to do) one has failed to achieve the target criterion precisely. Thus the difference between the two rules is a different commitment as to how one will react to seeing that one has missed one's target. The PT rule is more robust to learning dynamics and suggests that optimal monetary policy might best be implemented by explicit reference to the path of the price level rather than the inflation rate [13].

On the other hand, it would be interesting to see the extent to which simple price-level targeting rules compare to IT rules. In a recent paper Billi (2008) addresses this question, but does not analyze the conditions under which this types of rules guarantee determinacy.

[12] This result is coherent with Blanchard and Gali (2010) conclusions: when prices and wages are sticky, a Central Bank should target a linear combination of both.

[13] If the the Central Bank correctly understands agents' behavior, it can implement the optimal targeting criterion either based on IT or PT

Finally, a theoretical extension is to analyze the extent to which price-level targeting is desiderable in an open economy. There are some contributions on this topic (Cateau et al. (2009) and Coletti et al. (2008). Those studies, however, are based on country specific models and do not address this topic using a microfounded simple model, like the standard open economy model of Gali and Monacelli (2005).

6 Caveats of price-level targeting

According to the discussion of previous sections, price level targeting achieves better outcomes than inflation targeting under discretion. This result hinges on the fact that, with price level targeting, the Central Bank gains access to a mechanism to affect the private sector's expectations which is also present in the commitment case. This mechanism is given by the fact that, because in the price level targeting regime the Central Bank stabilizes deviations of prices from trend, the price level is (trend) stationary. Under inflation targeting and discretion, however, this is no longer the case. For the simple model we presented in section 3, this result is robust to changes in the parameters of interest in the model, such as the persistence of the cost-push shock and the degree of price stickiness.

In section 2 we review some of the recent literature on price level targeting and conclude that, for a large class of models, price level targeting performs better under discretion than inflation targeting. This evidence seems to point out, at least from a theoretical perspective, to a supremacy of price level targeting in environments in which the monetary authority cannot commit to future policies.

There are, however, a number of caveats to price level targeting. From a theoretical point of view, as mentioned before, the strength of price level targeting comes from the possibility to affect the expectations of private agents. Therefore, in models in which producers set prices according to past values of relevant variables such as inflation, price level targeting is less effective. In the limit, if all producers are backward-looking, price level targeting is ineffective.

Another difficulty with price level targeting arises from its implementation. Communicating a target in terms of the aggregate price level is a complicated task, and it may require a considerable length of time before the private sector correctly forms expectations about the evolution of inflation and the output gap from the announcement that monetary policy will seek to stabilize prices around a particular trend.

Finally, price level targeting arises as an interesting alternative when there is lack of commitment from the monetary authority to future policies. However, price level targeting itself is not immune to considerations of time-inconsistency. Consider the case in which, due to a negative cost-push shock, there is a deflation in the current period that will need to be offset with future inflations for the price level to return to its target. As explained, expectations of future inflation aid the Central Bank in stabilizing the economy. However, in future periods, the Central Bank will have to put up with positive levels of inflation, even if the shock has died out. This creates the same incentives for the monetary authority to rethink its policy as in the commitment case. In fact, given that the actual social loss function is determined by equation (3), if we allowed the Central Bank to reoptimize taking this loss function into account, it would change its policy in order to stabilize inflation. It is in this sense that the time-inconsistency problem prevails in the case of price level targeting.

7 Conclusions

In recent years there has been some discussion about the advantages of PT over IT. In particular, the conventional wisdom that PT is not able to stabilize in the short run output and inflation volatility has been challenged both by theocratical contributions as well as from quantitative research. For policymakers this regime is becoming an alternative for a long term policy framework (the Bank of Canada) as well as a temporary alternative to overcome problems related to the zero lower-bound.

Under some circumstances, PT can be an attractive alternative to IT. Its main advantage lies on the fact that PT acts as a commitment device when the central bank is unable to commit to its futures actions. When commitment is possible, however, IT can, in general, implement the optimal allocation. As an extension to the current literature, Preston (2008) shows that PT may have a better performance in an environment that departs from rational expectations, even if commitment is possible. In particular, if agents do not have rational expectations and learn adaptively, the optimal monetary policy might best be implemented by explicit reference to the path of the price level rather than the inflation rate.

There are, however, some caveats to be considered. First, the strength of PT comes from the possibility to affect the expectations of private agents. Therefore, in models in which producers set prices according to past values of relevant variables such as inflation, price level targeting is less effective. In the limit, if all producers are backward-looking, PT is ineffective. Second, another problem with PT arises from its implementation. Communicating a target in terms of the aggregate price level is a complicated task, and it may require a considerable length of time before the private sector correctly forms expectations about the evolution of inflation and the output gap from the announcement that monetary policy will seek to stabilize prices around a particular trend. Finally, PT arises as an interesting alternative when there is lack of commitment from the monetary authority to future policies. However, PT itself is not immune to considerations of time-inconsistency.

References

Ambler, S.: 2009, Price-level targeting and stabilization policy: a survey, *Journal of Economic Surveys* **23**, 974–997.

Billi, R.: 2008, Price-level targeting and risk management in a low-inflation economy, *Technical report*.

Blanchard, O. J. and Gali, J.: 2010, Labor markets and monetary policy: a New Keynesian model with unemployment, *American Economic Review: Macroeconomics* **2**, 1–30.

Carlstrom, C., Fuerst, T. and Paustian, M.: 2009, Inflation persistence, monetary policy and the Great Moderation, *Journal of Money, Credit and Banking* **41**.

Cateau, G., Kryvtsov, O., Shukayev, M. and Ueberfeldt, A.: 2009, Adopting Price-Level Targeting under Imperfect Credibility in ToTEM, *Working Paper 2009-17*, Bank of Canada.

Clarida, R., Gali, J. and Gertler, M.: 1999, The science of monetary policy - a New Keynesian perspective, *Journal of Economic Literature* **XXXVII**, 1661–1707.

Coenen, G. and Wieland, V.: 2004, Exchange-Rate Policy and the Zero Bound on Nominal Interest Rates, *American Economic Review* **94**, 80–84.

Coletti, D., Lalonde, R. and Muir, D.: 2008, Inflation targeting and price-level-path targeting in the global economy model: Some open economy considerations, *IMF Staff Papers* **55**, 326–338.

Covas, F. and Zhang, Y.: 2008, Price-level versus inflation targeting with financial market imperfections, *Working Paper 08-26*, Bank of Canada.

Dennis, R.: 2010, When is discretion superior to timeless perspective policymaking?, *Journal of Monetary Economics* **57**, 266–277.

Eggertsson, G. B. and Woodford, M.: 2003, The zero bound on interest rates and optimal monetary policy, *Brookings Papers on Economic Activity* **34**, 139–235.

Fillion, J. F. and Tetlow, T.: 1994, Zero inflation or price-level targeting? some answers from stochastic simulations on a small open-economy macro model, *Economic Behavior and Policy Choice under Price Stability*, Bank of Canada, pp. 129–166.

Fischer, S.: 1994, Modern central banking, *in* F. Capie and et. al. (eds), *The Future of Central Banking*, Cambridge University Press.

Gali, J.: 2008, *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework*, Princeton University Press.

Gali, J. and Monacelli, T.: 2005, Monetary policy and exchange rate volatility in a small open economy, *Review of Economic Studies* **72**, 707–734.

Gaspar, V., Smets, F. and Vestin, D.: 2007, Is time ripe for price level path stability?, *Working Paper 818*, European Central Bank.

Givens, G. E.: 2009, Which price level to target? strategic delegation in a sticky price and wage economy, *Journal of Macroeconomics* **31**, 685–698.

Haldane, A. and Salmon, C.: 1995, Three issues on inflation targets, *in* A. Haldane (ed.), *Targeting Inflation*, Bank of England, pp. 170–201.

Kryvtsov, O., Shukayev, M. and Ueberfeldt, A.: 2008, Adopting price-level targeting under imperfect credibility: An update, *Working Paper 2008-37*, Bank of Canada.

Lebow, D., Roberts, J. and Stockton, D.: 1992, Economic performance under price stability, *Working Paper 125*, Federal Reserve Board.

Lim, G. C.: 2009, Inflation targeting, *Australian Economic Review* **42**, 110–118.

McCallum, B. T.: 2000, Theoretical analysis regarding a zero lower bound on nominal interest rates, *Journal of Money, Credit and Banking* **32**, 870–904.

Nakov, A.: 2008, Optimal and simple monetary policy rules with zero floor on the nominal interest rate, *International Journal of Central Banking* **4**, 73–127.

Preston, B.: 2008, Adaptive learning and the use of forecasts in monetary policy, **32**.

Soderlind, P.: 1999, Solution and estimation of re macromodels with optimal policy, *European Economic Review* **43**, 813–823.

Svensson, L. E. O.: 1999, Price level targeting vs. inflation targeting: a free lunch?, *Journal of Money, Credit and Banking* **31**, 277–295.

Svensson, L. E. O.: 2003, Escaping from a liquidity trap and deflation: The foolproof way and others, *Journal of Economic Perspectives* **17**, 145–166.

Vestin, D.: 2006, Price-level versus inflation targeting, *Journal of Monetary Economics* **53**, 1361–1376.

Wolman, A. L.: 2005, Real implications of the zero bound on nominal interest rates, *Journal of Money, Credit and Banking* **37**, 273–96.

A Appendix

A.1 Policy function parameter values

The following table shows the values of the parameters of policy functions (4) - (9) and of the weights $\hat{\lambda}$ and $\tilde{\lambda}$ used in the numerical exercises described in the main text.

		Baseline, $\rho = 0.8$	Baseline, $\rho = 0$	$\kappa = 0.05$	$\kappa = 1$
IT + Comm.	a	0.6292	0.6292	0.9361	0.2685
	b	1.2542	0.6292	3.6198	0.341
	c	0.4195	0.4195	0.0936	0.537
	d	0.8361	0.4195	0.3620	0.6821
	λ	0.5	0.5	0.5	0.5
IT + Discr.	a	1	1	1	1
	b	0.7835	0.8182	4.3096	0.1018
	c	0	0	0	0
	d	2.5111	0.5455	2.0719	0.9788
	$\hat{\lambda}$	0.104	0.5	0.104	0.104
PT + Discr.	a	0.7062	0.6292	0.9536	0.3631
	b	1.2154	0.6292	3.7709	0.3307
	c	0.2652	0.4195	0.052	0.408
	d	1.1810	0.4195	0.8464	0.7227
	$\tilde{\lambda}$	1.5	0.672	9	0.7

Documentos de Trabajo	**Working Papers**
Banco Central de Chile	**Central Bank of Chile**
NÚMEROS ANTERIORES	PAST ISSUES

La serie de Documentos de Trabajo en versión PDF puede obtenerse gratis en la dirección electrónica: www.bcentral.cl/esp/estpub/estudios/dtbc. Existe la posibilidad de solicitar una copia impresa con un costo de $500 si es dentro de Chile y US$12 si es para fuera de Chile. Las solicitudes se pueden hacer por fax: (56-2) 6702231 o a través de correo electrónico: bcch@bcentral.cl.

Working Papers in PDF format can be downloaded free of charge from: www.bcentral.cl/eng/stdpub/studies/workingpaper. Printed versions can be ordered individually for US$12 per copy (for orders inside Chile the charge is Ch$500.) Orders can be placed by fax: (56-2) 6702231 or e-mail: bcch@bcentral.cl.

DTBC-600 Noviembre 2010
Vulnerability, Crisis and Debt Maturity: Do IMF Interventions Shorten the Length of Borrowing?
Diego Saravia

DTBC-599 Noviembre 2010
Is Previous Export Experience Important for New Exports?
Roberto Álvarez, Hasan Faruq y Ricardo A. López

DTBC-598 Noviembre 2010
Accounting for Changes in College Attendance Profile: A Quantitative Life-cycle Analysis
Gonzalo Castex

DTBC-597 Octubre 2010
Fluctuaciones del Tipo de Cambio Real y Transabilidad de Bienes en el Comercio Bilateral Chile - Estados Unidos
Andrés Sagner

DTBC-596 Octubre 2010
Distribucion de Probabilidades Implicita en Opciones Financieras
Luis Ceballos

DTBC-595 Octubre 2010
Extracting GDP signals from the monthly indicator of economic activity: Evidence from Chilean real-time data
Michael Pedersen

DTBC-594 Octubre 2010
Monetary Policy Under Financial Turbulence: An Overview
Luis Felipe Céspedes, Roberto Chang y Diego Saravia

DTBC-593 Septiembre 2010
The Great Recession and the Great Depression: Reflections and Lessons
Barry Eichengreen

DTBC-592 Septiembre 2010
Evidencia de Variabilidad en el Grado de Persistencia de la Política Monetaria para Países con Metas de Inflación
Benjamín García

DTBC-591 Septiembre 2010
Mercados de Financiamiento a los Hogares en el Desarrollo de la Crisis Financiera de 2008/2009
Gabriel Aparici y Fernando Sepúlveda

DTBC-590 Agosto 2010
The Financial Accelerator Under Learning and the Role of Monetary Policy
Rodrigo Caputo, Juan Pablo Medina y Claudio Soto

DTBC-589 Julio 2010
Conventional Calibration Versus EDF Calibration
Felipe Córdova

DTBC-588 Julio 2010
Nowcasting with Google Trends in an Emerging Market
Yan Carrière-Swallow y Felipe Labbé

DTBC-587 Julio 2010
Inflation Targeting in Financially Stable Economies: Has it been Flexible Enough?
Mauricio Calani, Kevin Cowan y Pablo García S.

DTBC-586 Junio 2010
Heterodox Central Banking
Luis Felipe Céspedes, Roberto Chang y Javier García-Cicco