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## Is time ripe for price level path stability?

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EUROPEAN CENTRAL BANK

EUROSYSTEM

## WORKING PAPER SERIES

NO 818 / OCTOBER 2007

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by Vitor Gaspar,  
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by Vítor Gaspar<sup>2</sup>,  
Frank Smets<sup>3</sup>  
and David Vestin<sup>4</sup>



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**Abstract:** In the paper, we provide a critical and selective survey of arguments relevant for the assessment of the case for price level path stability (PLPS). Using a standard hybrid new Keynesian model we argue that price level stability provides a natural framework for monetary policy under commitment. There are two main arguments in favour of a PLPS regime. First, it helps overall macroeconomic stability by making expectations operate like automatic stabilizers. Second, under a price level path stability regime, changes in the price level operate like an intertemporal adjustment mechanism, reducing the magnitude of required changes in nominal interest rates. Such a property is particularly relevant as a means to alleviate the importance of the zero bound on nominal interest rates. We also review and discuss the arguments against price level path stability. Finally, we also found, using the Smets and Wouters (2003) model which includes a wide variety of frictions and is estimated for the euro area, that the price level is stationary under optimal policy under commitment. The results obtain when the quasi-difference of inflation is used in the loss function, as in the hybrid new Keynesian model. Overall, the arguments in favour of or against price level path stability depend on the degree of dependence of private sector expectations on the characteristics of the monetary policy regime.

**Key words:** Price Level Stability, Expectations, Adaptive Learning.

**JEL Codes:** E52, D83.



## Non-technical summary

According to the conventional wisdom in central banking circles, price level path stability is not an appropriate goal to delegate to an independent central bank. There is strong intuition behind this claim. The idea 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 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 volatility of inflation. Moreover, in the presence of price and wage stickiness, moving around inflation requires pushing output above or below potential as the case may be. Hence, the intuition goes, price level path stability would induce increased volatility of inflation and output gaps, compared to a regime of inflation targeting. The common practice of letting bygones be bygones is, thus, justified. Past deviations from target are effectively ignored. If there is some impulse leading to a one-off jump to the price level there is no effort to reverse it. Instead, inflation targeting aims at bringing projected (and actual) inflation back to target. Under such a regime it should be true that over a sufficiently long period average inflation comes close to target inflation. Nevertheless, the uncertainty about the price level would rise without limit.

In contrast, under a price level path target, the monetary authority would consistently aim at correcting deviations from target. In case the price level is above the price level norm, monetary policy aims at a lower average inflation rate for a period of time; in case it is below the norm, monetary policy aims at an above average inflation rate. Under such a regime both average inflation and the price level would be well anchored at low frequencies.

In this paper, we critically and selectively review arguments that are relevant for assessing the case for price stability, i.e. the case for stability around a price level path. We identify two main arguments in favour of such a regime. First, under rational expectations price level stability helps overall macroeconomic stability by making expectations operate like automatic stabilizers. After a positive (negative) shock to the price level, firms, correctly anticipating a persistent policy response that will reverse the effect on the price level, adjust their inflation expectations down (up), thereby mitigating the impact of the shock. Moreover, focusing on the price level path contributes to circumventing credibility problems that central banks may face.

Second, a commitment to a reversion to a price level path helps to alleviate the zero bound on nominal interest rates. Here the reason is that the changes in the price level help the inter-temporal adjustment. The mechanism described above implies that after a negative shock to the price level inflation expectations adjust upward, thereby depressing real interest rates, which in turn contributes to the stabilisation of the economy. Overall, the conventional wisdom that relies on a trade-off between low frequency uncertainty of the price level and high frequency volatility of inflation and the output gap disregards the fundamental importance of endogenous expectations for monetary policy making. In the paper we present arguments that make the case for price level stability dependent on the endogenous character of expectations. Such arguments are of general interest as they highlight the importance of endogenous expectations for the conduct of monetary policy.

We then turn to investigating two arguments that have been used against the case for price level targeting. First, the superior performance of price level stability crucially hinges on the (assumed) credibility of the reversion in the price level. It is argued that if expectations are mainly backward-looking, the additional benefits of price-level stability will be small. Moreover, the transitional costs of establishing the credibility of a regime of price level path stability may be too large. Relying on our own recent research in models with adaptive learning, we present examples that this is not generally the case. We show that, under adaptive learning on the part of firms, the track record obtained under such a regime leads to a similar case for price level path targeting. We also show that the question of regime transition and the associated costs is important but not decisive. A second argument is that price level stability would make past policy mistakes very costly to unwind. The literature suggests, however, that through the endogenous expectation formation process price level targeting may automatically correct past policy mistakes.

We perform our analysis mostly within the framework of the hybrid New Keynesian Phillips curve, abstracting from other frictions such as nominal and real labour market rigidities. Such frictions will typically increase the costs associated with reverting the price level following a shock. However, they also increase the benefits of price level stability to the extent that the impact of inflation shocks on inflation is reduced. In particular, when agents and the central bank are learning and inflation shocks may



persist and become costly to control, the benefits of price level stability may outweigh the costs. Moreover, those costs can be reduced by lengthening the horizon for price level stability accordingly. Using a more elaborate estimated New Keynesian model, that incorporates a wide range of frictions, including nominal wage stickiness, habit formation and investment adjustment costs, we find that optimal policy under commitment continues to deliver a stationary price level, as it does in the simple new Keynesian model. The results obtain using an ad-hoc loss function in the semi-difference of inflation, the output gap and interest rate changes

Finally, it is frequently argued that a strategy based on price level stability would be hard to communicate and to explain to the public. In the paper we have argued that, on the contrary, a focus on the price level allows the central bank to follow a consistent communication strategy that circumvents the strains of commitment.

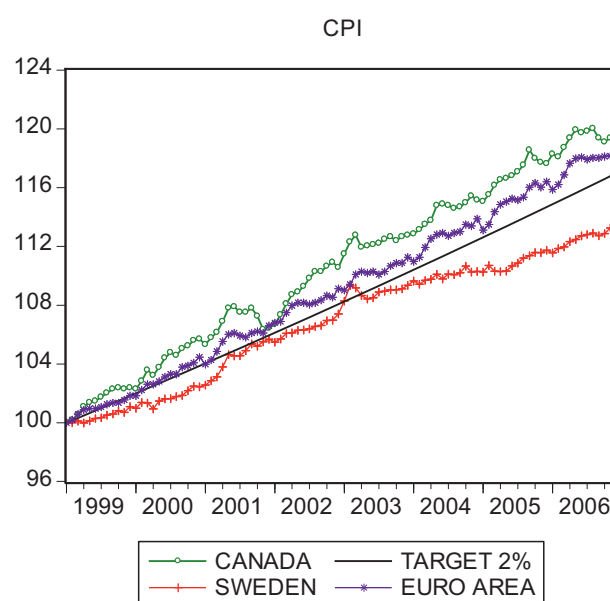
## 1. Introduction

According to the conventional wisdom in central banking circles, price level path stability is not an appropriate goal to delegate to an independent central bank. There is strong intuition behind this claim. The idea 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 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 volatility of inflation. Moreover, in the presence of price and wage stickiness, moving around inflation requires pushing output above or below potential as the case may be. Hence, the intuition goes, price level path stability would induce increased volatility of inflation and output gaps, compared to a regime of inflation targeting. The common practice of letting bygones be bygones is, thus, justified. This consensus was, for example, reflected in the paper that Stanley Fisher contributed to the conference celebrating the tercentenary of the Bank of England in 1994, where he said: "Price level targeting is thus a bad idea, one that would add unnecessary short-term fluctuations to the economy." The trade-off between low frequency price (level) variability and higher frequency inflation and output (gap) volatility was also found in a number of small macroeconomic models, developed in the 1990s (for example Lebow, Roberts and Stockton (1992), Fillion and Tetlow (1994), Haldane and Salmon (1995) and Laxton, Ricketts and Rose (1994)).

As noted above the main difference between inflation targeting and price level path targeting is the relevance each gives to past departures from target. Under inflation targeting bygones are bygones. Past deviations from target are effectively ignored. If there is some impulse leading to a one-off jump to the price level there is no effort to reverse it. Instead, inflation targeting aims at bringing projected (and actual) inflation back to target. Thus, under an inflation targeting regime it should be true that over a sufficiently long period average inflation comes close to target inflation. Such outcome requires symmetric random shocks and a monetary policy authority that consistently and symmetrically aims at the target. Nevertheless, the uncertainty about the price level would rise without limit. This is also illustrated by the recent experience of central banks like the Sveriges Riksbank, the Bank of Canada and the

European Central Bank, which each have defined price stability with reference to an annual increase of consumer prices by two percent. Figure 1 plots the development of the consumer price level in each of those three economies since 1999 (when the ECB was established). The average inflation rate over the period from 1999 till 2006 is indeed very close to two percent in each of those economies. However, the uncertainty about the price level over a period of eight years is much higher, as highlighted by the range of price levels at the end of 2006.

**Figure 1**  
**Consumer prices in Canada, the euro area and Sweden since 1999**



In contrast, under a price level path target, the monetary authority would consistently aim at correcting deviations from target.<sup>5</sup> In case the price level is above the price level norm, monetary policy aims at a lower average inflation rate for a period of time; in case it is below the norm, monetary policy aims at an above average inflation rate.<sup>67</sup> Under such a regime both average inflation and the price level would be well

<sup>5</sup> The price level target can be defined as a deterministically increasing price path. A case for literal price level stability may be based on the analogy with the system of weights and measures. It relates to the use of money as a unit of account. A very powerful formulation is due to Francois Leblanc (1690): "if there is something in the world that ought to be stable it is money, the measure of everything that enters the channels of trade. What confusion would not be in a state where weights and measures frequently changed? On what basis and with what assurance would a person deal with another, and which nations would come to deal with people who lived in such disorder?"

<sup>6</sup> Average here refers to the average inflation rate implicit in the definition of the normative price level path.

anchored at low frequencies. Low uncertainty over long horizons may be crucial for the long-term financial planning of home purchase or retirement. Such a line of enquiry would lead to a number of questions like: how important are the benefits from low long-term price level uncertainty? Would price level stability make a difference for the use of long-term debt contracts or the duration of investment projects?<sup>8</sup> These are interesting and important questions. They are also beyond the scope of this paper.<sup>9</sup>

Instead the path that we want to pursue in this paper stems from Svensson (1999), Svensson and Woodford (2005) and Clarida, Gali and Gertler (1999). Svensson (1999) was the first to emphasize that, under rational expectations, price level targeting might lead to lower inflation and to identical output variability. Price level targeting would, thus, deliver a free lunch. The intuition is that, within a model that incorporated a Lucas-supply function, delegating a price level target to a central bank helps solving the time inconsistency problem. The argument put forward by Svensson (1999) is very strong and, hence, persuasive. It implies that, even if society does not care about price stability *per se*, it may still be well advised to focus on price level stability. Moreover, Clarida, Gali and Gertler (1999) and Svensson and Woodford (2005) have shown that in a simple New-Keynesian model, optimal monetary policy under commitment leads to a stationary price level.<sup>10</sup> The intuition is clear. When the central bank is committed to stabilize the price level, rational expectations become automatic stabilizers. The mechanism operates as follows. Assume that a deflationary or disinflationary disturbance leads to a fall in the price level relative to target. Economic agents observing the shock understand that the central bank will correct the

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<sup>7</sup> In a recent report on the Riksbank's monetary policy, Giavazzi and Mishkin (2006) suggest that following the persistent undershooting of the inflation target in Sweden, monetary policy should lean towards more expansionary policy. In his reply, Governor Ingves (2006) replied that a time-varying inflation target would be too difficult to communicate and that it would complicate inflation expectation formation and may make it more difficult to anchor expectations. A price level target would be a natural way of implementing such a policy.

<sup>8</sup> Similar questions are raised in Bank of Canada (2006).

<sup>9</sup> In 3 July 1933, US President Roosevelt stated his commitment to long run price stability in no uncertain terms: "The United States seeks the kind of dollar which a generation hence will have the same purchasing power and debt paying power as the dollar we hope to attain in the near future." The address was a wireless communication to the World Economic Conference that had started on June 12, in London (available from <http://www.presidency.ucsd.edu/?pid=14679>). It is clear from other documents that Roosevelt aimed at inflating the economy after a period of deflation. Such a goal is much easier to attain in case mean reversion is a permanent feature of the policy regime. See McCallum (2005).

<sup>10</sup> See the monumental Woodford (2003) for a complete presentation.

disturbance through higher inflation than otherwise in the near future. As a result, inflation expectations increase, which helps to mitigate the initial impact of the deflationary shock, spreads it over time and contributes to overall stability. Under a credible regime implying reversion in the price level, inflation expectations operate as automatic stabilizers. The beneficial impact of a credible price level target on current inflation and inflation expectations was typically lacking in the analysis with backward-looking models reported above.

The new Keynesian model is currently the main workhorse for monetary policy analysis. Its relevant friction, leading to monetary non-neutrality, is sticky prices and/or wages. The main alternative, in the literature, is sticky information. Ball, Mankiw and Reis (2005) explore a model that belongs to this class with foundations rooted in behavioural economics. Interestingly they find that optimal monetary policy stabilizes the price level path in response to demand and productivity shocks. In general terms, optimal monetary policy, in their model, may be characterized as flexible targeting of the price level.

Our objective in this paper is modest. In the next section, we review the case in favour of price level stability, using a standard hybrid New Keynesian Phillips curve, which following the seminal book by Woodford (2003) has become the workhorse in most monetary policy analysis. We follow Svensson (1999) and assume that society does not care about price stability *per se*. In this set-up, we first explain in Section 2.1 how the optimal monetary policy under commitment is characterised by mean reversion in the price level and how assigning a price level stability objective can implement the first-best monetary policy as in Vestin (2006) and Røisland (2005). In Section 2.2, we then turn to the argument that anchoring inflation expectations by means of price level targets could also help to address the problem posed by the zero lower bound on interest rates.<sup>11</sup> This follows the early intuition of Duguay (1994) and Coulombe (1997) that announcing a target path for the price level would help promote expectations of a future rebound in inflation even in the event that the economy

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<sup>11</sup> In the context of the renewal of its Inflation Control Target on 23 November 2006, the Bank of Canada (2006) mentions this argument as one of the main reasons for studying the relative merits of specifying a price-level target as opposed to an inflation target.



should fall into a lower bound situation, which would in turn help resist deflation and a profound downturn in the first place. Wolman (2005) and Eggertson and Woodford (2005) make this case in the context of a version of the New Keynesian model discussed in Section 2.1.<sup>12</sup> Finally, in Section 2.3 we use the Smets and Wouters (2003) model to show that the price level remains stationary under optimal policy under commitment, even in a model which includes a wide variety of frictions and is estimated for the euro area. The result obtains when the quasi-difference of inflation is used in the loss function, as in the hybrid New Keynesian model. .

In section 3 we then turn to investigating two arguments that have been used against the case for price level targeting. First, the superior performance of price level stability crucially hinges on the (assumed) credibility of the reversion in the price level. It is argued that if expectations are mainly backward-looking, the additional benefits of price-level stability will be small.<sup>13</sup> Moreover, the transitional costs of establishing the credibility of a regime of price level path stability may be too large. Following our own on-going research (Gaspar, Smets and Vestin, 2007), we address these issues in Section 3.1, by extending the basic New Keynesian framework with adaptive learning. A second argument is that the benefits of price level targeting depend too much on unrealistic assumptions regarding central bankers' ability to control the price level. The idea here is that, because of uncertainty about the state and the functioning of the economy, policy makers make mistakes and generate volatility in the price level. Under price level targeting they will be forced to create additional volatility in the real economy in order to undo the effects of their own mistakes on the price level. In Section 3.2, we rely on recent results by Aoki and Nikolov (2006) to address this issue. Finally, Section 4 contains our main conclusions.

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<sup>12</sup> A related argument that we do not discuss is that price level stability reduces the risk of a debt deflation spiral. While deeper and more efficient financial markets allow households and firms to better smooth their expenditure patterns and hedge against the various risks they are subjected to, they also lead to higher indebtedness of certain agents, making them more sensitive to unexpected changes in both asset and goods prices. If such unexpected asset price collapses lead to deflationary expectations and falling prices, the real debt burden will typically further rise and a Fisherian debt-deflation spiral could start. A focus on price level stability ensures that the real redistribution due to nominal shocks will be (perceived as) temporary and may thereby reduce the probability of a debt deflation spiral. Of course, the importance of this argument will also depend on the source of the shocks.

<sup>13</sup> See, for example, Barnett and Engineer (2000).



Before turning to the analysis of Sections 2 and 3, it is worth recalling that the current focus in central banking on stabilising inflation rather than the price level is a relatively new phenomenon that arose in the wake of the Great Inflation of the 1970s. One could argue that price level stability is the natural fiduciary alternative to the commodity standards of the pre-World War II economies.<sup>14</sup> Research on the Gold Standard shows that in this period the price level was indeed mean reverting and that periods of falling prices were not necessarily associated with lower output growth or higher output losses. Indeed, various papers by Bordo and Redish (2003, 2004) have demonstrated that deflations in the pre-1914 classical gold standard period in the United Kingdom and Germany were primarily driven by productivity-driven increases in aggregate supply. For the United States, these results generally prevail with the exception of a banking-panic-induced demand-driven deflation episode in the mid-1890s. Bordo and Filardo (2004) generalize this finding to a panel of over twenty countries for the past two centuries. With the exception of the interwar period they find that deflation was generally benign. Interestingly, Berg and Jonung (1999) argue that the adoption of a price level target in Sweden during the Great Depression has alleviated the output losses associated with deflation in this country.

## **2. The case for price-level stability**

### **2.1. The optimality of price level stability in the New Keynesian model**

A case for the optimality of price level stability can be based on the benchmark New Keynesian model, as, for example, in Woodford (2003). This model rests on a number of assumptions. First, the production sector of the economy is composed by a large number of identical monopolistically competitive firms. Monopolistic competition prevails because firms produce differentiated goods that are imperfect substitutes. Second, the monopolistically competitive firms are price setters. They set prices before knowing demand and are committed to satisfy demand at the set price. As in Calvo (1983), a proportion of firms are allowed to re-set their prices at the end of each period. This proportion is exogenously given and constant over time. Third, firms that are not allowed to re-set prices adjust their prices to offset a fraction of the average price change observed in the period. Such partial indexation to past inflation is

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<sup>14</sup> The monetary literature of the early days of the 20<sup>th</sup> century (Fisher, Keynes and Wicksell) shows as much.

justified by the need to match the degree of inflation persistence found in aggregate data, but is not in line with micro-evidence. Fourth, firms produce using labour only and technology exhibits diminishing returns. Fifth, all goods contribute in a symmetric way to the utility of the representative consumer.

The model delivers a strong case for price stability (Goodfriend and King, 1997, 2001 and Rotemberg and Woodford, 1997). Given the symmetry of preferences and technology, an efficient equilibrium is characterized by equal production of all goods and unitary relative prices. Due to staggered price setting, inflation creates inefficiencies as relative prices and associated quantities will differ across producers. Price stability restores the efficient equilibrium.

In this section, we lay out the basic model and show that optimal monetary policy is characterized by mean reversion in the price level. In other words, price level stability is implied by optimal policy.<sup>15</sup> As extensively discussed in Woodford (2003), under rational expectations, the set of micro-economic assumptions considered above gives rise to the following standard New Keynesian model of inflation dynamics:

$$(1) \quad \pi_t - \gamma\pi_{t-1} = \beta(E_t\pi_{t+1} - \gamma\pi_t) + \kappa x_t + u_t,$$

where  $\pi_t$  is inflation,  $x_t$  is the output gap and  $u_t$  is a cost-push shock (assumed i.i.d.). Furthermore,  $\beta$  is the discount rate,  $\kappa$  is a function of the underlying structural parameters including the degree of Calvo price stickiness,  $\alpha$ , and  $\gamma$  captures the degree of intrinsic inflation persistence due to partial indexation in the goods market. Galí and Gertler (1999) and Galí, Gertler and Lopez-Salido (2001) have shown that such a hybrid New Keynesian Phillips curve fits the actual inflation process in the United States and the euro area quite well.

In addition, we assume that the central bank uses the following loss function to guide its policy decisions:

$$(2) \quad L_t = (\pi_t - \gamma\pi_{t-1})^2 + \lambda x_t^2.$$

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<sup>15</sup> The benefits from price level targeting in a rational expectations framework were first highlighted by Svensson (1999) in the context of a neo-classical framework. Ditmar and Gavin (2000) show that a free lunch also arises when the aggregate supply function has the New Keynesian form with current expectations of future inflation rates.

Woodford (2003) has shown that, under rational expectations and the assumed microeconomic assumptions, such a loss function can be derived as a quadratic approximation of the (negative of the) period social welfare function, where  $\lambda = \kappa/\theta$  measures the relative weight on output gap stabilization and  $\theta$  is the elasticity of substitution between the differentiated goods. We implicitly assume that the inflation target is zero. To keep the model simple, we also abstract from any explicit representation of the transmission mechanism of monetary policy and simply assume that the central bank controls the output gap directly.

Next, we solve for optimal policy under rational expectations with and without commitment by the central bank.

Defining  $z_t = \pi_t - \gamma\pi_{t-1}$ , equations (1) and (2) can be rewritten as:

$$(1') \quad z_t = \beta E_t z_{t+1} + \kappa x_t + u_t$$

$$(2') \quad L_t = z_t^2 + \lambda x_t^2.$$

*Optimal monetary policy under discretion.*

If the central bank can not commit to its future policy actions, it will not be able to influence expectations of future inflation. In this case, there are no endogenous state variables and since the shocks are iid, the rational expectations solution (which coincides with the standard forward-looking model) must have the property  $E_t z_{t+1} = 0$ . Thus:

$$(1'') \quad z_t = \kappa x_t + u_t$$

Hence, the problem reduces to a static optimization problem. Substituting (1'') into (2') and minimizing the result with respect to the output gap, implies the following policy rule:

$$(3) \quad x_t = -\frac{\kappa}{\kappa^2 + \lambda} u_t.$$

Under the optimal discretionary policy, the output gap only responds to the current cost-push shock. In particular, following a positive cost-push shock to inflation, monetary policy is tightened and the output gap falls. The strength of the response

depends on the slope of the New Keynesian Phillips curve,  $\kappa$ , and the weight on output gap stabilization in the loss function,  $\lambda$ .<sup>16</sup>

Using (3) to substitute for the output gap in (1'') and the definition of  $z_t$  implies:

$$(4) \quad \pi_t = \gamma\pi_{t-1} + \frac{\lambda}{\kappa^2 + \lambda} u_t.$$

Note that in this case inflation follows an AR(1) process and there is a unit root in the price level:

$$(5) \quad p_t = (1 + \gamma)p_{t-1} - \gamma p_{t-2} + \nu u_t$$

where  $\nu = \lambda/(\kappa^2 + \lambda)$ . Under discretionary monetary policy the price level does not revert to a constant mean.

#### *Optimal monetary policy under commitment*

Under discretion there is no inertia in policy behaviour. In contrast, if the central bank is able to credibly commit to future policy actions, optimal policy will feature a persistent “history dependent” response. In particular, Woodford (2003) shows that optimal policy will now be characterized by the following equation:

$$(6) \quad z_t = -\frac{\lambda}{\kappa}(x_t - x_{t-1}).$$

In this case, the expressions for the output gap and inflation can be written as:

$$(7) \quad x_t = \delta x_{t-1} - \frac{\kappa}{\lambda} u_t, \text{ and}$$

$$(8) \quad \pi_t = \gamma\pi_{t-1} + \frac{\lambda(1 - \delta)}{\kappa} x_{t-1} + \delta u_t,$$

where  $\delta = (\tau - \sqrt{\tau^2 - 4\beta})/2\beta$  and  $\tau = 1 + \beta + \kappa^2/\lambda$ . Comparing equation (3) and (7), it is clear that under commitment optimal monetary policy is characterized by history dependence in spite of the fact that the shock is temporary. The intuitive

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<sup>16</sup> The reaction function in (3) contrasts with the one derived in Clarida, Gali and Gertler (1999). They assume that the loss function is quadratic in inflation (instead of the quasi-difference of inflation,  $z_t$ ) and the output gap. They find that, in this case, lagged inflation appears in the expression for the reaction function, corresponding to optimal policy under discretion.

reason for this is that under commitment perceptions of future policy actions help stabilize current inflation, through their effect on expectations. By ensuring that, under rational expectations, a positive cost-push shock is associated with a decline in inflation expectations, optimal policy manages to spread the impact of the shock over time.

One can show that in this case, the optimal reaction function can also be written as a function of past price levels and the cost-push shock:

$$(9) \quad x_t = -(\kappa\delta/\lambda)(p_{t-1} - \bar{p}_{t-2} + u_t)$$

In words, the central bank tightens policy in response to a positive cost-push shock and in response to positive deviations of past prices from its target. Moreover, the optimal policy under commitment implies a stationary price level, as long as the degree of indexation is not perfect (i.e.  $\gamma$  is less than one). In this case, the solution for the price level can be written as:

$$(10) \quad p_t = (\gamma + \delta\beta^{-1})p_{t-1} - \gamma\delta\beta^{-1}p_{t-2} + \delta u_t,$$

where the expression for  $\delta$  is given above.

**Table 1**  
Calibration parameters for the benchmark case<sup>17</sup>

$\beta$	$\gamma$	$\lambda$	$\theta$	$\alpha$	$\phi$	$\kappa$	$\sigma$
0.99	0.5	0.002	10	0.66	0.02	0.019	0.004

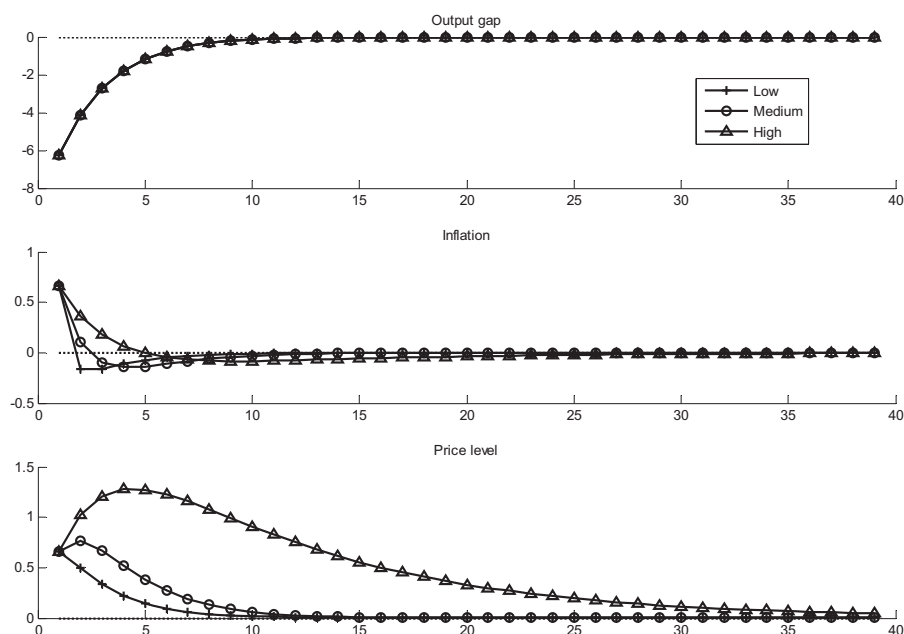
Figure 2 below plots the response of the price level to a standard-deviation cost-push shock for different degrees of indexation. The calibration of the other parameters is taken from Gaspar, Smets and Vestin (2006) as in Table 1. As also shown by Woodford (2003, p500), the price level may exhibit a hump-shaped response, depending on the degree of indexation. The higher the degree of indexation, the more hump-shaped the response of the price level to a cost-push shock. However,

<sup>17</sup> We justify our choices in Gaspar, Smets and Vestin (2006).

eventually it always returns to baseline as long as the degree of indexation is less than one.

**Figure 2**

Responses to a cost-push shock under different degrees of indexation



Note: Low, medium and high refers to the degree of indexation of prices to lagged inflation of 0.1, 0.5 and 0.9 respectively.

This feature of optimal policy may seem counterintuitive. It is often argued that if one wishes to stabilise inflation and does not care about the absolute level of prices, then surprise deviations from the long-run average of inflation rate should not have any effect on the inflation rate that policy aims for subsequently: one should let bygones be bygones, even though this means allowing the price level to drift to a permanently different level. “Undoing” past deviations simply creates additional, unnecessary variability in inflation. This would be correct if the commitment to correct past deviations had no effect on expectations. However, if price setters are forward looking as in this New Keynesian model, the anticipation that a current increase in the general price level will predictably be undone, gives firms a reason to moderate the current adjustment of its own price. As a result, it is optimal to return the price level to its baseline in order to reduce equilibrium inflation variability.



In the previous section, we have shown that price level stability is a feature of optimal policy under commitment in the basic hybrid New Keynesian model, even if there is some degree of indexation and there is lagged inflation dependence. However, in practice, there are incentives to depart from such a path. The temptation is apparent from Figure 2. For all cases plotted, there are periods when inflation is below target and, at the same time, output is below potential. In such periods the policy path under commitment looks inappropriate. It is possible to get simultaneously inflation closer to target and output closer to potential. Hence, according to common sense, policy should depart from its path under commitment. In such circumstances policy-makers face the strains of commitment. In other words, it is not easy for the central bank to commit to optimal policy. There is an incentive to re-optimize as time passes by and let bygones be bygones. In such a discretionary environment, assigning an explicit price level target to the central bank may be a transparent way to enforce the appropriate history dependence of monetary policy. Moreover, as pointed out by Svensson (1999), a price level target would also eliminate any existing inflation bias under discretionary policy.

Indeed, Vestin (2006) shows that, when the central bank is operating in a discretionary environment, price level targeting outperforms inflation targeting in the basic forward-looking New Keynesian model with zero indexation. He shows that when there is no persistence in the cost-push shocks, the commitment equilibrium can be fully replicated. Røisland (2007) extends the results of Vestin (2006) to the hybrid case with indexation to past inflation as discussed above, and shows that also in this case it is beneficiary to assign a hybrid price level target to the central bank. In this case, the targeting rule can be written as a modified instantaneous loss function of the form  $(p_t - \bar{p}_{t-1})^2 + \bar{\lambda}x_t^2$ , where  $\gamma$  is the degree of indexation as before and  $\bar{\lambda}$  is a modified weight on the output gap<sup>18</sup>. Finally, Svensson and Woodford (2005) analyse optimal targeting rules in a related model and show that such a rule includes a term in the price level in addition to the more traditional terms in inflation and output gap volatility. The weight on the price level term in the optimal targeting rule is in general time-varying and depends on the shadow price of sticking to past promises. This time-varying weight underlines the notion that in general the horizon over which

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<sup>18</sup>Røisland (2006) also shows the optimality of inflation targeting when there is full indexation ( $\gamma=1$ ).

the central bank attempts to revert the price level will depend on the state of the economy and the shocks that have hit the economy in the past.

Intuitively, these results highlight that price level targeting introduces history dependence and a stationary price level, both of which are characteristics of the commitment solution as mentioned above.

It is worthwhile to pause to examine how focusing on the price level helps overcoming the strains of commitment. The argument becomes intuitive after careful examination of Figure 2. Looking simultaneously at the first and third panels it is apparent that optimal policy under commitment involves keeping output below potential as long as the price level is above target. Hence, communication of the rationale for optimal policy under commitment becomes easier as soon as one shifts the focus from inflation to the price level. Clearly, as Figure 2 makes clear, the time horizon associated with the return of the price level to target may be very long, in particular in the case of a relatively high partial indexation parameter,  $\gamma$ .

It could be argued that it is difficult to reconcile such a long time horizon with a reasonable confidence that the favorable effects on private expectations will materialize. Given such a long time horizon it would be difficult for the private sector to figure out whether policymakers' behavior was consistent with their commitments. On this important consideration three remarks are in order. First, clearly the result presented is fully consistent with rational expectations. However, it is still possible to argue that the information and knowledge assumptions underlying rational expectations are particularly demanding under a price level stability regime. Hence, it is important to add a second remark. Figure 2 illustrates how a price level regime provides an information rich environment. The idea is that after a cost-push shock a relatively short period of inflation above target, depending on the degree of partial indexation, should be expected. After that, inflation should remain persistently below target in order to ensure correction in the price level. It is precisely because it takes so long to correct the price level that it is possible to monitor the process of adjustment well before the eventual correction materializes.

In any case, the reliance of the case for price level stability on credibility must be taken seriously. Below, in section 3.1., we find that the case for a price stability regime remains intact when the private sector departs from rational expectations and relies instead on adaptive learning. Finally, it is intuitively likely that a price level stability regime would reduce the degree of indexation, which by itself would shorten the time horizon associated with corrections in the price level.

## 2.2. Price level stability, the zero lower bound and deflationary spirals

An important additional argument in favour of a commitment to price level stability is related to its benefits in alleviating the potentially negative implications for macro-economic stability of the zero lower bound on nominal interest rates. The argument is very intuitive. As highlighted by Duguay (1994) and Coulombe (1999), under price level targeting the price level plays the role of an intertemporal price reducing the need for variations in the nominal interest rate.<sup>19</sup>

To see this, it is instructive to write down the standard forward-looking IS-curve that results from intertemporal consumption smoothing. This IS curve links the output gap to the ex-ante real interest rate:

$$(11) \quad x_t - x_T = -\sigma \sum_{i=0}^{T-1} R_{t+i} + \sigma E_t(p_T - p_t) + \varepsilon_t$$

where  $x_t$  is the output gap as before,  $R_t$  is the nominal short-term interest rate and  $\varepsilon_t$  is a demand shock.<sup>20</sup> Assume now there is a negative demand shock that reduces current output and the current price level. Under credible price level targeting this will generate an expected increase in the price level ( $p_T > p_t$ ), as the price level is expected to return to its target. As a result, for a given nominal interest rate, the real interest rate will fall stimulating current output. This will have an automatic stabilising effect on the economy. The net outcome of this stabilising effect is that nominal interest rates need to adjust less and as a result the frequency of hitting the zero lower bound for a given target rate of inflation will be less. Moreover, when nominal interest rates are stuck at zero, the price level will continue to operate as an automatically stabilising intertemporal price.

Eggertson and Woodford (2005) formally analyse the benefits of price level targeting in a forward-looking New Keynesian model like the one we analysed in Section 2.1. When the degree of indexation is zero, the optimal targeting rule (7) can be written in terms of the price level:

$$(12) \quad x_t = -\frac{\kappa}{\lambda}(p_t - p^*)$$

Eggertson and Woodford (2005) show that this simple price level targeting rule does almost as well as the optimal non-linear rule under a zero lower interest rate constraint. Under the optimal non-linear rule, the price level target ( $p^*$ ) is time-

<sup>19</sup> Coulombe (1999) gives the concrete example of his grandfather, who would decide to buy durable goods based on whether the price level was relatively low.

<sup>20</sup> See Svensson (2006) for a similar analysis in the context of Japan's liquidity trap.

varying and depends on the length of time during which the lower zero constraint is binding. Eggertson and Woodford (2005) show that under their calibration the price level rule (12) creates losses that are only 9 percent of the losses that would ensue under a zero inflation target and only one fifth of the losses that would ensue under a two percent inflation target.<sup>21</sup> Equally importantly, the alternative policy rule (7), which without zero lower bound would also implement the commitment equilibrium, does much worse than the price level targeting rule. In fact, this rule does even worse than the zero inflation target rule. The reason for this is that this rule mandates deflation when there is growth in the output gap. This in turn implies that the central bank will deflate once out of a liquidity trap. However, this is exactly the opposite to what is optimal: in order to get out of the trap, the central bank needs to commit to generating higher than average inflation.

Overall, this analysis shows that while in normal times, the alternative ways of implementing the optimal policy under commitment may be equivalent, there are important additional benefits of communicating the optimal policy in terms of a price level target. In particular, it makes the implementation of such a target in a situation where the zero lower interest rate constraint is binding much more credible, as agents will have experienced the actual implementation of a price level targeting regime. As highlighted above, a credible price level targeting rule is a particularly effective way of reducing the risk of falling in a deflationary trap when nominal interest rates are bound at zero. As highlighted by Berg and Jonung (1999), the Swedish experience with a price level target during the interwar period may be an example of how those benefits work in practice.

### **2.3. Going beyond the basic New Keynesian model**

Woodford (2003, page 501) has argued that the result of the optimality of price level stationarity in the basic New Keynesian model is relatively fragile given that the welfare does not depend at all on the range of variation in the absolute level of prices. However, the intuition that a monetary policy that does not let bygones be bygones has strong stabilising effects on inflation and economic activity, in particular in the presence of a potentially binding zero lower constraint on nominal interest rates is very strong and is likely to survive in more general characterisations of the economy as long as expectations matter. While full mean-reversion in the price level may not

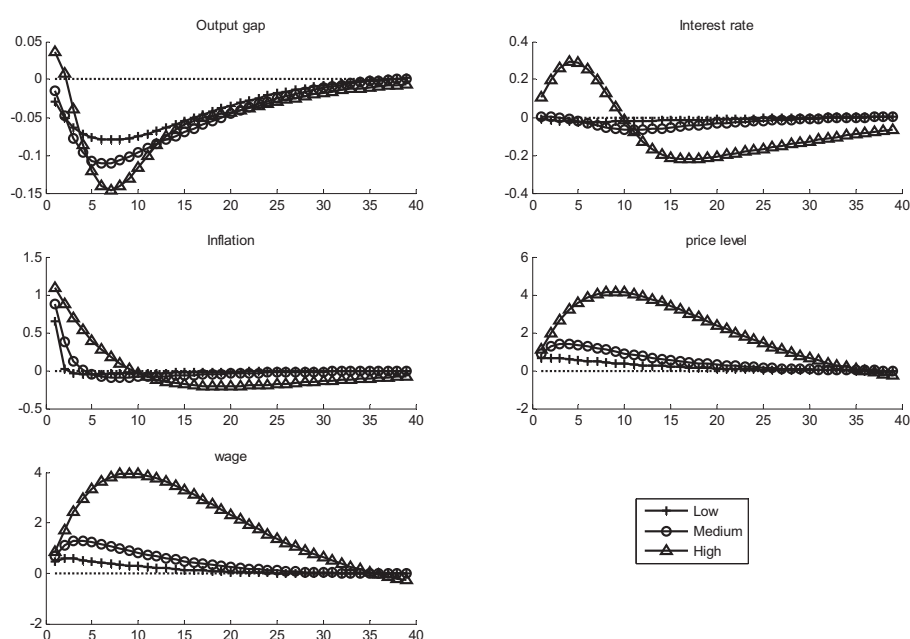
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<sup>21</sup> Similarly, Wolman (2005) shows in the basic New Keynesian model that a simple rule that targets the price level reduces the cost of the zero lower bound to almost zero even when the inflation target is zero. Reifschneider and Williams (1999) show that a price level targeting rule also works quite well in the US econometric model of the Federal Reserve Board.

be a feature of the fully optimal policy in more general models, a price-level path targeting regime is a simple, easy-to-communicate way of implementing a policy that ensures an appropriate level of history dependence. Moreover, a flexible regime that allows for a gradual return of the price level to its target depending on the shocks hitting the economy is likely to reduce the costs associated with a stricter implementation.

**Figure 3**

Impulse response to a price-mark-up shock in the Smets-Wouters model



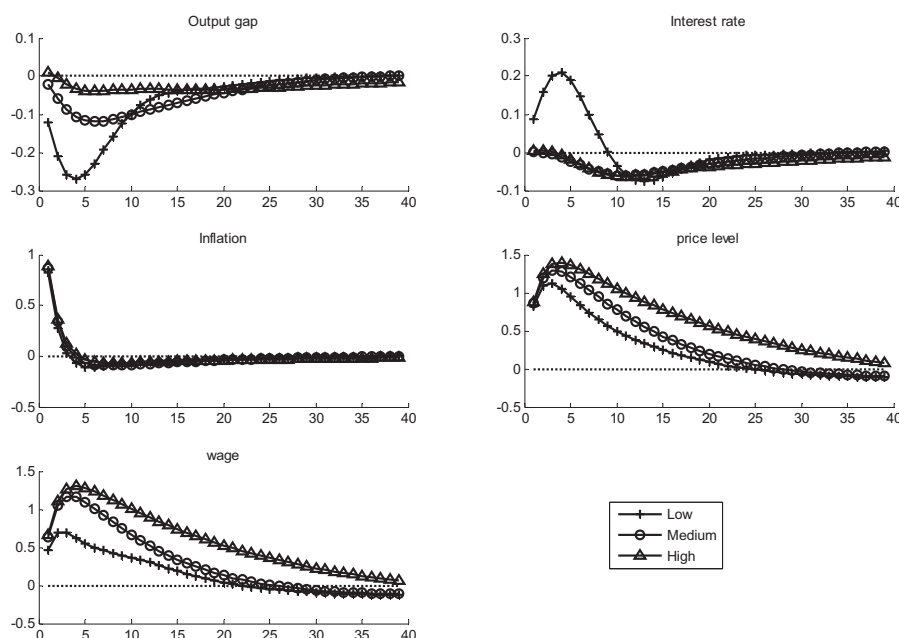
Notes: Low, medium and high correspond to different degrees of inflation indexation: 0.1, 0.5 and 0.9 respectively. The impulse responses are derived under the assumption that the central bank minimises a loss function in the variability of the semi-difference of inflation, the output gap and interest rate changes under commitment. The respective weights are 0.9, 0.1 and 0.05.

These findings can be illustrated using a much more elaborate model like Smets and Wouters (2003). This model incorporates a hybrid New Keynesian Phillips curve like the one analysed in Section 2.1., but also many other frictions such as nominal wage stickiness, habit formation and investment adjustment costs, which make it costly to revert the price level. Figure 3 shows the impulse response of the output gap, the short-term interest rate, inflation, the price level and the nominal wage level to a one percent price-mark-up shock, when the central bank optimises under commitment an ad-hoc loss function in the semi-difference of inflation, the output gap and interest

rate changes. It is immediately clear that in spite of the other real and nominal frictions the optimal commitment policy again induces a stationary price level. As in the simple New Keynesian model of Section 2.1, the higher the degree of inflation indexation, the more hump-shaped the price-level response and the longer it takes before prices revert back to baseline. Note that the medium case depicted in the Figure corresponds to the empirical estimate of the degree of indexation (i.e. 0.5). Reducing the weight on the variability of the output gap and interest rate changes shortens the horizon over which the price level is returned to baseline, confirming the analysis of Batini and Yates (2003) and Smets (2003). Those studies also show that the horizon over which mean reversion in the price level is to be achieved will depend on the structure of the economy. For example, if the Phillips curve of the economy is relatively flat, it is beneficial to have a relatively longer horizon. Figure 4 plots the impulse response functions to a price mark-up shock under different degrees of nominal wage rigidity. It is clear that also in this case higher nominal wage rigidity increases the time it takes for prices to return to baseline.

**Figure 4**

Impulse response to a price-mark-up shock under different degrees of nominal wage rigidity



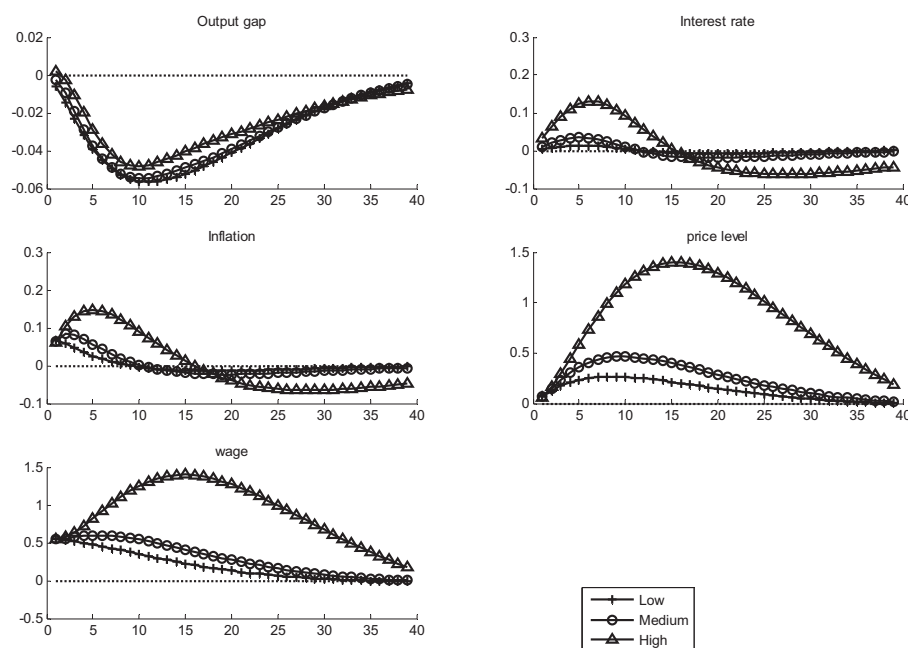
Notes: Low, medium and high correspond to different degrees of nominal wage stickiness: 0.2, 0.7 and 0.9 respectively. See also the note to Figure 3.



Finally, a similar reversal of the price level is also obtained in response to other shocks such as a wage mark-up shock as shown in Figure 5 below.

**Figure 5**

Impulse response to a wage-mark-up shock in the Smets-Wouters model



Notes: Low, medium and high correspond to different degrees of inflation indexation: 0.1, 0.5 and 0.9 respectively. See also the note to Figure 3.

Taking into account the differences between the basic new Keynesian model and Smets and Wouters (2003) the similarity between the panels of Figure 3, depicting the output gap, inflation and the price level, and Figure 2 is remarkable. It suggests that the importance of endogenous expectations is still decisive in complex environments. The intuition remains that focusing on the price level allows the monetary authority to spread over time the effects of shocks that create a trade-off between low and stable inflation and the maintenance of output close to potential. Many authors have emphasised the importance of lagged inflation dependence for the cost-benefit analysis of price level path targeting. The results above suggest that the issue is not so much whether to focus on price level path targeting but how long the mean reversion process should be allowed to take.

Moreover, it is worth recalling that the automatic indexation of prices to past inflation that underlies the lagged inflation dependence in the hybrid New Keynesian Phillips

curve discussed in Section 2.1. is not very much supported by the micro data. Typically, around 80% of observed prices in the consumer price index do not change in a given month. Finally, the degree of indexation is likely to be regime dependent. More specifically, it is likely that the degree of lagged inflation dependence would fall under a price level path targeting regime.

Before turning to Section 3, it is also worth mentioning that a number of studies have analysed the properties of simple policy rules that include a price-level term in large-scale macro-econometric models. One prominent example is Williams (2000), which uses the Federal Reserve's FRBUS model and shows that a simple feedback rule on the price level also has positive stabilising effects in such a large, more extensive model.<sup>22</sup>

### **3. Two objections to price level path stability.**

In this section, we discuss a number of counter arguments. We first discuss the argument that price level path stability is too costly when there is imperfect credibility. A related argument is that the transitional costs of moving to a price level path stability regime are too large in the presence of private sector learning. We then examine the argument that in the face of uncertainty and learning by the central bank, price level stability is too costly because it forces the central bank to instill volatility in the economy following its own mistakes.

#### **3.1. Unrealistic reliance on credibility**

A number of papers have argued that the benefits of price level stability disappear or are greatly reduced when the degree of credibility of the monetary policy regime is limited or expectations are backward-looking rather than forward-looking.<sup>23</sup> For example, in early studies of simple policy rules in an economy with backward-looking expectations, Haldane and Salmon (1995) and Lebow, Roberts and Stockton (1992) find that feedback rules on the price level result in higher short-term variability for both inflation and output growth.<sup>24</sup> In a later simulation study, Black, Macklem and Rose (1997) shows that adding a price level gap term to the monetary policy reaction function can deliver significant reductions in the volatility of output, inflation and

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<sup>22</sup> Another example is Black, Macklem and Rose (1998). See also section 3.1.

<sup>23</sup> This is also the main concern raised in Bank of Canada (2006).

<sup>24</sup> Another relevant study is Fillion and Tetlow (1994).

interest rates if there is a small effect of the price level gap on inflation expectations. MacLean and Pioro (2001) explicitly investigate to what extent the “free lunch” result of Svensson (1999) and others is robust to changes in assumptions about the way in which price expectations are formed and the “degree” of credibility. They model imperfect credibility as a process whereby private sector inflation expectations are a weighted average of forward-looking rational expectations, the inflation target and past inflation. They find that with model-consistent expectations, it is possible to reduce the variability in inflation, output and nominal interest rate. Moreover, incorporating credibility effects specifically tied to the price level target leads to even greater reductions in variability. At the same time, they confirm that when agents are highly backward-looking, introducing a price level target results in increased output and interest rate variability. Finally, using the policy model of the Board of Governors of the Federal Reserve System, also Williams (1999) finds that targeting the price level rather than the inflation rate generates little additional cost in terms of output and inflation variability. However, the characteristics of efficient policy rules depend critically on the assumption regarding expectations formation. In particular, the policy rule that is most efficient when the model assumes forward-looking expectations, turn out to be the worst when fixed adaptive expectations are assumed. The robustness of inflation and price level rules (or a combination of the two) is explicitly investigated in Jääskelä (2005). He shows that, if the policy maker overestimates the degree of forward-looking expectations, the optimal hybrid rule appears to be the worst performing rule. The standard Taylor rule that fails to introduce inertia avoids bad outcomes and is shown to be the most robust to model uncertainty.

One criticism of the studies discussed above is that the expectation formation process is typically assumed to be fixed. In general, expectations formation will respond to the characteristics of the monetary policy regime. Even if expectations are backward-looking, in the sense that they are based on regressions using past data as in the adaptive learning literature, the estimated regression model that agents use will change as the monetary policy regime is changed. In such a case, it is important to investigate whether the long-run benefits from moving to a regime of price level stability and accordingly anchored expectations outweigh the transitional costs as agents learn about the new regime and adjust their expectation formation process.

In the rest of this section, we perform this cost-benefit analysis in the context of the the basic New Keynesian model of Woodford (2003) discussed in Section 2.1. Following Gaspar, Smets and Vestin (2007), we assume adaptive learning rather than rational expectations, i.e. agents form their expectations by running regressions on past inflation and prices. Equations (5) and (10) in Section 2.1 show that in both the discretionary and commitment equilibrium of the hybrid New Keynesian model, the

price level can be written as a second-order autoregressive process. In the discretionary equilibrium there is a unit root in the price level, whereas in the commitment equilibrium prices are mean reverting. We therefore analyse the following experiment. Assume that agents start in a discretionary equilibrium. In this equilibrium the estimated coefficients on the price level process will be given by equation (5). Under the assumed calibration of Table 1, this implies that the first-order autoregressive coefficient is 1.5, whereas the second-order coefficient is -0.5. We then assume the central bank decides to implement the commitment equilibrium by following a rule like (9), which delivers price level stability. Two questions can now be answered. Will the equilibrium converge to the rational expectations equilibrium under commitment? If so, how long does it take and how important are the transitional costs?

We rely on the fact that, under rational expectations, both in the case of commitment and discretion, the stochastic process for the price level can be written as an AR (2) process (see section 2.1.). Thus, under adaptive learning we assume that the agents estimate an equation like:

$$p_t = \alpha_1 p_{t-1} + \alpha_2 p_{t-2} + \varepsilon_t$$

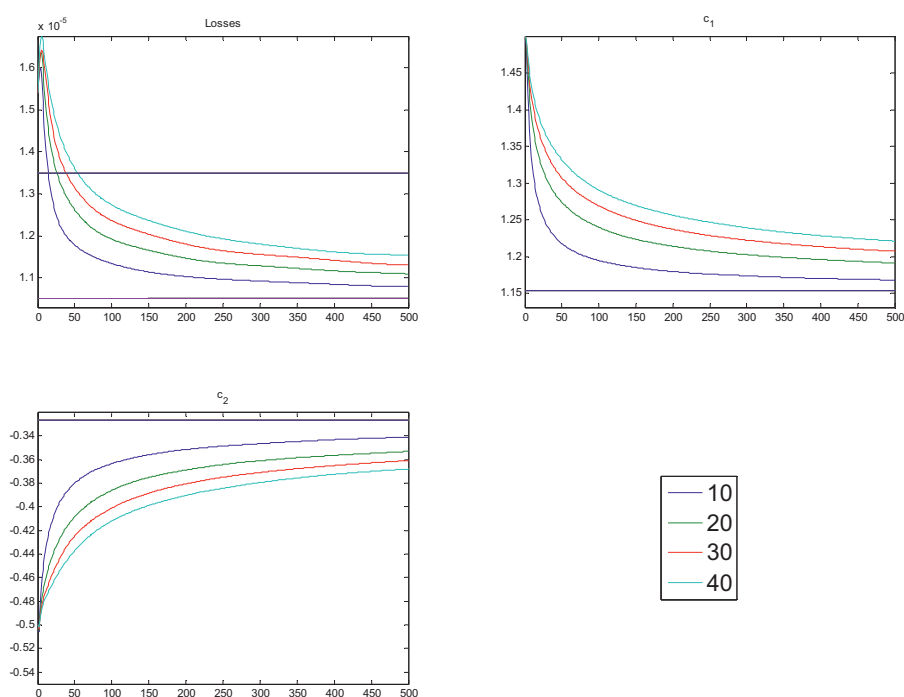
Turning to the first question, the answer is affirmative. In order to answer the question Gaspar, Smets and Vestin (2007) consider recursive least squares (RLS) learning and show, using the methods of Evans and Honkapohja (2001), that under the baseline calibration assumptions used above (and reasonable alternative assumptions) the associated dynamic system is indeed e-stable. In other words, one can prove that under recursive least squares learning the equilibrium will converge to the rational expectations equilibrium under commitment. This shows that even under adaptive learning (where the agents are completely backward looking), eventually the benefits of price level stability can be achieved in the long run. This result is illustrated in Figure 6 using stochastic simulations for the calibrated model. Figure 6 displays mean-dynamics responses for our system.

From equation (10), it is clear that, under RE and commitment, the autoregressive coefficients are 1.15 and -0.35 respectively. Under RLS Figure 6 shows the estimated coefficients converging slowly to these values. As a result, the price level becomes eventually stationary.

Figure 6 is also informative regarding the second question raised above. It shows the convergence process of the estimated autoregressive parameters in the estimated price equation, as well as the mean loss incurred in the convergence process as a function of

the initial gain. The initial gain will determine how fast agents learn the new regime. It can be considered as the weight agents put on past data relative to the data in the new regime. If the announcement of a price level stability regime is credible, agents will put little weight on the past experience and the convergence will be faster.

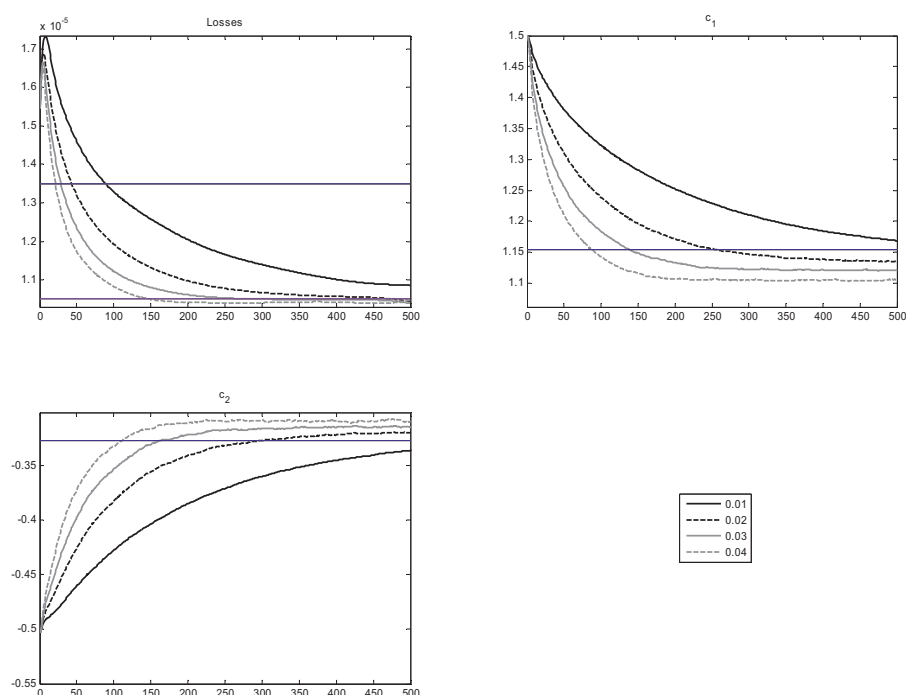
**Figure 6**  
Convergence to the commitment regime:  
Losses and estimated autoregressive coefficients



Notes: The different convergence paths correspond to different initial estimation periods:  $T=10, 20, 30$  and 40 quarters.

Figure 6 highlights that the speed of convergence will strongly depend on the speed of learning. When a relatively high weight is put on recent new observations the estimated coefficients converge quite rapidly. The upper left panel shows that because of learning there is an initial increase in the loss relative to the discretionary equilibrium (horizontal line at about 1.35), but after a few periods, as agents learn about the new regime, losses start falling and eventually fall below the discretionary outcome, converging to the losses under commitment.

**Figure 7**  
Convergence with constant-gain learning



Notes: The different convergence paths correspond to different gains in the constant-gain learning algorithm: gain=0.001, 0.01, 0.02, 0.03 and 0.04.

Recursive least squares learning may not be the most attractive learning scheme when considering possible changes in policy regimes. Figure 7 plots a similar experiment in the case of constant gain learning where the constant gains considered vary from 0.01 (slow learning) to 0.04 (fast learning). The size of these gains are consistent with empirical evidence on the speed of learning in the formation of inflation expectations (e.g. Orphanides and Williams, 2007). In this case there is no guarantee that the learning equilibrium converges to the rational expectations commitment equilibrium. However, in each case the equilibrium loss converges to a loss level that is close to the one under commitment.

Table 2 reports the time it takes for the losses to fall below the discretionary losses as well as the present discounted value of the difference in loss under price level stability and the discretionary policy, for different initial estimation periods, constant gains, degrees of indexation and degrees of price stickiness. It is worth noting that when learning is slow (as, for example, illustrated by the column with a constant gain of 0.01 in Table 2), the transition process may take very long and on balance it may be too costly to move to a price level stability regime. However, this case is not likely to



be empirically relevant for two reasons. First, empirical evidence on the speed of learning suggests that higher gains of 0.02 or above are more appropriate to describe the inflation expectations formation process. Under such gains the net benefits are positive. Second, communication by the central may facilitate the transition by speeding up the learning process. In the benchmark simulation with an initial estimation period of 5 years, it takes about 7 years before the losses fall under those of the discretionary equilibrium. Similar results are obtained with a constant gain of 0.03. In both cases, the net benefit from moving to price level stability is positive with a discount factor of 0.99. This learning period can be shorted to 3-4 years if the initial estimation period is shorter or the speed of learning faster. A lower degree of indexation reduces the time it takes for the losses to be smaller than under the discretionary equilibrium, but the sensitivity is limited. In contrast, the duration and the net benefit seem to be more sensitive to changes in the degree of price stickiness. Increasing the degree of price stickiness to an average duration of one year lengthens the break-even period by more than a year. Clearly those calculations also depend on the assumed discount factor.<sup>25</sup>

**Table 2**

	Initial estimation period			Constant gain			
	T=10	T=20	T=30	C=0.01	C=0.02	C=0.03	C=0.04
Baseline	15 -0.014	27 -0.007	40 -0.003	90 0.006	44 -0.004	29 -0.010	22 -0.014
$\gamma = 0.3$	13 -0.015	26 -0.008	38 -0.003	89 0.006	44 -0.004	29 -0.010	21 -0.015
$\gamma = 0.7$	16 -0.013	28 -0.006	42 -0.002	93 0.006	46 -0.004	30 -0.010	22 -0.014
$\alpha = 0.6$	13 -0.015	22 -0.009	33 -0.005	78 0.003	37 -0.006	25 -0.012	19 -0.016
$\alpha = 0.7$	17 -0.012	30 -0.005	44 -0.001	104 0.008	49 -0.002	32 -0.009	25 -0.013

Notes: The first entry gives the time in quarters it takes before the loss under the price level stability regime is lower than that under the discretionary regime. The second entry gives the discounted loss with a discount factor of 0.99. A negative number implies it is beneficial to implement a price level path stability regime.

<sup>25</sup> Preliminary results from Gaspar, Vestin and Smets (2007) show that convergence is faster under the price level rule compared to the history-dependence rule.

### 3.2. Uncertainty and price level stability

When the central bank faces uncertainty about the state and structure of the economy and the monetary transmission mechanism, it may make mistakes and may not be able to control the price level perfectly. One can argue that in such circumstances, price level stability would increase the cost of such central bank mistakes, as the central bank is forced to undo their effects on the price level. When prices are sticky, this will tend to increase the volatility of the real economy.

Again, this argument is only partially true as it does not take into account the positive ex ante effects price level stability may have on expectation formation by the private sector in response to such central bank mistakes. Moreover, one should also take into account the positive effect of the commitment to price level stability on the central bank's incentive not to make mistakes.

Aoki and Nikolov (2005) evaluate the performance of three popular monetary policy rules when the central bank is learning about the parameter values of a simple New Keynesian model. In particular, both the central bank and the private sector learn about the slopes of the IS and Phillips curve by recursive least squares.<sup>26</sup> This model uncertainty also introduces uncertainty about the state of the economy, such as estimates of the natural real interest rate. The three policies are the optimal non-inertial rule, the optimal history-dependent rule and the optimal price-level targeting rule. Under rational expectations the last two rules implement the fully optimal equilibrium by improving the output-inflation trade-off. The optimal history-dependent rule is a targeting rule similar to the one exhibited in equation (6), whereas the optimal price level targeting rule relates the price level to the output gap.

When imperfect information about the model parameters is introduced, Aoki and Nikolov (2005) find that the central bank makes monetary policy mistakes, which affect welfare to a different degree under the three rules. Somewhat surprisingly, the optimal history-dependent rule is worst affected and delivers the lowest welfare. It turns out that under this rule, endogenous persistence due to the rule works as a propagation mechanism of policy mistakes, in particular in response to demand shocks. In contrast, price level targeting performs best under learning and maintains the advantages of conducting policy under commitment. It turns out that adopting an integral representation of rules designed under full information is desirable because they deliver the beneficial output-inflation trade-off of commitment policy while being robust to implementation errors. Integral control elements improve the

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<sup>26</sup> The Phillips curve is similar to the one analysed before, but with no indexation. The IS curve is a forward-looking IS curve as in Woodford (2003).

performance of feedback rules when, for example, there are errors in estimating the steady state of the system. In Aoki and Nikolov (2005), a rule involving integral term performs better because it reverses past policy mistakes. These benefits are even greater in a forward-looking model as they help stabilise inflation expectations.

Importantly, Aoki and Nikolov (2005) show that those benefits of responding to a price level target continue to dominate when an interest rate variability term is introduced in the central bank's objective function or inflation indexation is included in the Phillips curve. While under perfect information, mean reversion in the price level is no longer fully optimal, a rule implementing it is optimal when the central bank is learning about the model's parameter values.

Overall, the results in Aoki and Nikolov (2005) suggest that the benefits of price level targeting are enhanced rather than reduced when the central bank faces uncertainty about the structure of the economy. These results are confirmed by Orphanides and Williams (2007). They find that a first-difference rule, which is akin to a price level targeting rule, is a robust rule with respect to uncertainty about private sector learning and estimates of the natural interest rate and the natural rate of unemployment. Similarly, Gorodnichenko and Shapiro (2005) argue that a price level target – which is a simple way to model a commitment to offset errors – can serve to anchor inflation even if the public believes the central bank is overly optimistic about shifts in potential output. The paper shows that price level targeting is superior to inflation targeting in a wide range of situations when potential output is uncertain.

#### **4. Conclusions**

We have provided a critical and selective survey of arguments that are relevant for assessing the case for price stability, i.e. the case for stability around a price level path. A regime of price level path stability is most compatible with the functioning of a market economy. Intuitively it provides a neutral numeraire allowing the market mechanism to operate fully. Therefore, it is not surprising that such regime was advocated, by classical economists like Knut Wicksell, Irving Fisher and John Maynard Keynes, as a superior alternative even relative to the Gold Standard.

In the paper, we have identified two main arguments in favour of such a regime. First, under rational expectations price level stability helps overall macroeconomic stability by making expectations operate like automatic stabilizers. After a positive (negative) shock to the price level, firms, correctly anticipating a persistent policy response,

adjust their inflation expectations down (up), thereby mitigating the impact of the shock. Moreover, focusing on the price level path contributes to circumventing credibility problems that central banks may face. Second, a commitment to a reversion to a price level path helps to alleviate the zero bound on nominal interest rates. Here the reason is that the changes in the price level help the inter-temporal adjustment. The mechanism described above implies that after a negative shock to the price level inflation expectations adjust upward, thereby depressing real interest rates, which in turn contributes to the stabilisation of the economy. Overall, the conventional wisdom that relies on a trade-off between low frequency uncertainty of the price level and high frequency volatility of inflation and the output gap disregards the fundamental importance of endogenous expectations for monetary policy making. In the paper we present arguments that make the case for price level stability dependent on the endogenous character of expectations. Such arguments are of general interest as they highlight the importance of endogenous expectations for the conduct of monetary policy.

We have also investigated arguments made against price level path stability. A first argument against price level path stability is that it relies on the assumed credibility of the regime. Only with unrealistic levels of credibility would expectations operate like automatic stabilizers. Relying on our own recent research in models with adaptive learning, we present examples that this is not generally the case. We show that, under adaptive learning on the part of firms, the track record obtained under such a regime leads to a similar case for price level path targeting. We also show that the question of regime transition and the associated costs is important but not decisive. A second argument is that price level stability would make past policy mistakes very costly to unwind. We refer to Aoki and Nikolov (2006) which shows that, in a model where both the central bank and the private sector are learning about the relevant parameters of the economy, price level targeting automatically corrects past policy mistakes.

We have performed our analysis mostly within the framework of the hybrid New Keynesian Phillips curve, abstracting from other frictions such as nominal and real labour market rigidities. Such frictions will typically increase the costs associated with reverting the price level following a shock. However, they also increase the benefits of price level stability to the extent that the impact of inflation shocks on

inflation is reduced. In particular, when agents and the central bank are learning and inflation shocks may persist and become costly to control, the benefits of price level stability may outweigh the costs. Moreover, those costs can be reduced by lengthening the horizon for price level stability accordingly. Using the model of Smets and Wouters (2003), that incorporates a wide range of frictions, including nominal wage stickiness, habit formation and investment adjustment costs, we found that optimal policy under commitment delivers a stationary price level, as it does in the simple new Keynesian model. The results obtain using an ad-hoc loss function in the semi-difference of inflation, the output gap and interest rate changes

Finally, it is frequently argued that a strategy based on price level stability would be hard to communicate and to explain to the public. In the paper we have argued that, on the contrary, a focus on the price level allows the central bank to follow a consistent communication strategy that circumvents the strains of commitment. It does seem to us that the public at large finds it much easier to focus on prices rather than on inflation. Working in first differences seems to be a common professional hazard only amongst economists.

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