ISSN: 2281-1346

Department of Economics and Management

DEM Working Paper Series

Unmoored expectations and the price puzzle

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 # 154 (03-18)

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economiaweb.unipv.it

March 2018

Unmoored expectations and the price puzzle

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February 2018

Abstract

We explore the possibility that the price puzzle - the positive response of prices to a negative monetary policy shock- arises in the presence of unmoored expectations. Looking at the pre-Great Recession period, employing a VAR analysis, we compare the behavior of prices after a monetary policy shock in countries with clearly defined nominal anchors (Canada, New Zealand, Sweden, United Kingdom, Switzerland and EMU) to their behavior in countries that, at that time, did not possess any such anchor (Japan and United States). While in this last group we find evidence of a price puzzle, in the first, starting from the period when this anchor was set, we do not find such a perverse dynamic. We argue that those countries characterised by clearly defined nominal anchors, having anchored inflation expectations, have managed to rule out the persistent increase in the price level.

1 Introduction

In VAR analysis, puzzling responses of economic variables (generally prices) to monetary policy shocks are usually thought to be the consequence of a misspecified central bank's policy reaction function (Sims, 1992). The proposals to solve such puzzles deal generally with adding (previously omitted) variables in the VAR that help overcome the inadequate description of the central bank's policy function.

This paper intends to further investigate the puzzling responses of prices to monetary policy shocks. Throughout the analysis we consider a VAR in its simplest form containing just three variables: the (log of) real GDP (Y), (the log of) the GDP deflator (P) and the policy rate (R). As many others, we think that the omitted variable, whose exclusion could determine the price puzzle, deals with inflation expectations. However, we suspect that the puzzle's severity varies with the degree of the anchoring of inflation expectations by the central bank. In particular we distinguish among three different states: anchored, contained and unmoored expectations. When inflation expectations are firmly anchored we find, from previous works and from our

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empirical analysis, that there is no evidence of any price puzzle, since the central bank manages to keep the inflation process under control. However, in the presence of a central bank that acts managing expectations and which succeeds in containing but not firmly anchoring them, there is a price puzzle which, however, disappears once a proxy for inflation expectations is included in the VAR. Finally, when expectations are unmoored, the inflation process is completely unbound and even the inclusion of further variables does not avoid the puzzling responses. This happens, for example, when considering the pre-Volcker period in the United States.

The paper is organised as follows. Section 2 reexamines VAR evidence for the United States through a brief review of the literature on the price puzzle for this country. We also compare price puzzle evidence from the United States and the Euro area in the pre-Great Recession period. The tentative explanation for the different results we get from these two countries is discussed deeply in Section 3 which highlights the role of inflation expectations, borrows from the literature the definitions for anchored, contained and unmoored expectations and connects these definitions with the monetary regimes in place in different countries. Section 4 contains the empirical analysis devoted to check if and how the evidence on the price puzzle has changed in a host of countries after they adopted clearly defined nominal anchors. In Section 5 we consider a DSGE model with a cost channel that delivers a price puzzle. We want to find out if inflation stabilization has the potential, by anchoring expectations, to make the price puzzle disappear even in the presence of a cost channel. We show that a crucial role in this sense is played by the magnitude of Calvo parameters.

2 The price puzzle in the United States: evidence from the literature

According to the conventional wisdom, the price puzzle anomaly is given by the misspecification of the systematic part of policy. In particular, the VAR turns out to be misspecified if it fails to include a proxy for future inflation. According to Sims (1992) the price puzzle was the result of policy endogeneity: "policy authorities might know that inflationary pressure is about to arrive and contract to dampen the effects of these pressures. Then prices would rise after the monetary contraction (though by less than they would have without the contraction (p. 988-9)". When inflation expectations are not included in the VAR, the results of endogenous and/or anticipatory responses by the central bank emerge. Sims (1992) suggested the inclusion of a commodity price index, since this could contain information about future inflation that, correctly specifying the VAR, resolves the puzzle. Other authors detect different variables that could be of help to the central bank to forecast future inflation (such as inflation expectations from various surveys) or try to account for the large information set typically used by a central bank in taking its decisions. The factor-augmented VAR (FAVAR) approach, for example, going into this direction, should always be of help in avoiding these puzzling responses-provided they are truly due to omitted information which are essential in the monetary authority's decision process.[1] Others correct the policy shock to take account of endogeneity/anticipatory movements.[2]

[1] See, among the others, Bernanke et al. (2005) and Boivin et al. (2009).
[2] See Romer and Romer (1994).

Here, and throughout the paper, we limit our empirical investigation to the years before the Great Recession. A simple VAR analysis, in fact, would not be suited to study monetary policy effects in a zero lower bound era when non-standard monetary tools were employed.

In this section we review the papers that deal, directly or indirectly, with the price puzzle in the United States. We collect them in different tables according to the sample period they refer to. Table 1 includes the pre-Volcker period evidence, Table 2 the (whole) sample covering both the Great Inflation and the Great Moderation, Table 3 focuses just on the years after the Great Inflation (from 1982 on). Each table is organised as follows. In the first and in the second column you find, respectively, the authors of the paper and the sample period analysed. In the third column there is the empirical technique employed (based on VAR) and the variables included; in the last column there is a Y or a N according to the presence or not of a price puzzle in the impulse response functions.

As Table 1 shows, there is always evidence of the price puzzle in the pre-Volcker sample and, what is more, it does not disappear even when a proxy for inflation expectations is included or a FAVAR approach is employed[3]. As Hanson (2004) stresses, the practice to avoid the price puzzle including additional variables, such as commodity prices, does not work for all sub-sample periods, and especially in the pre-1980 period.

If the sample period is not limited to the Great Inflation but is extended to the Great Moderation years (see Table 2) there is the price puzzle but it disappears when a larger information set is used or when commodities prices or the output gap (see Giordani, 2004) or a new measure of monetary policy shock free from endogenous or anticipatory movements (see Romer and Romer, 1994) are included.

According to Hanson (2004), examining the causes and cures of the price puzzle employing a sample that contains both the pre- and post-1979 period may be inappropriate. In fact, in the period 1979-82, the Fed changed its operating procedure passing from federal funds rate targeting to non borrowed reserves targeting. This shift could have changed both the policy reaction function and the variables the Fed reacted to in these two subsamples. For this reason, Table 3 focuses just on the post-1982 period and it shows how the price puzzle is not that evident: a monetary policy shock still produces a price puzzle that, however, is seldom statistically significant and, adding variables sometimes solves the puzzle (see Balke and Emery, 1994), some others produces output puzzles (see Boivin and Giannoni, 2006) or it limits the puzzle to a short initial period (see Barth and Ramey, 2002).[4] Other times, however, adding variables or commodity prices does not solve the puzzle at all: this is the case, for example, when the years just before the start of the Great recession are included (see Milcheva, 2013).

To sum up: the evidence of a price puzzle is more clear cut in the pre-1979 sample when adding other

[3]These results refer to a VAR with a Choleski identification. Employing this identification and adding expected inflation, Castelnuovo and Surico (2010) find a price puzzle which is not statistically significant. They find that the price puzzle unambiguously disappears when both expected inflation is added in a VAR and a sign restriction identification strategy is followed.

[4]According to Boivin and Giannoni (2006), since the beginning of the eighties the impulse responses from a VAR analysis deliver a much lower impact of a monetary policy shock on output and inflation. The larger response by the Fed to inflation expectations, preventing non fundamental sunspots fluctuations, could have allowed a more contained answer of economic variables to the shock. In this setting, even the price puzzle might have become weaker and, being inflation expectations crucial in the central bank decision process, a proxy for them could result to be essential for the system to be correctly specified and for the price puzzle to disappear.

Table 1: United States, pre-Volcker sample

Author	sample period	methodology and variables	price puzzle?
Balke and Emery (1994)	1960-1979	VAR: GDP, deflator, fed rate,NR,TR	Y
		VAR: GDP, deflator, *com prices*, fed rate,NR,TR	Y
Giordani (2004)	1966q1-1979q1	VAR: Gap, inflation, fed rate	Y
Boivin and Giannoni (2006)	1959q1-1979q3	VAR: GDP, inflation, *com prices*, fed rate	Y
		FAVAR	Y
Hanson (2004)	1959:1-1979:10	VAR: IP, CPI, fed rate	Y
Barth and Ramey (2002)	1959:1-1979:9	VAR: IP, price level, *com prices*, M2, fed rate	Y
Castelnuovo and Surico (2010)	1966q1-1979q3	VAR: output gap, defl inflation, fed rate	Y
	1968q4-1979q3	VAR: *SPF exp inflation*, output gap, defl inflation, fed rate	Y (not signif.)

Table 2 United States, whole period

Author	sample period	methodology and variables	price puzzle?
Thapar (2008)	1976q1-1997q4	VAR: GDP, deflator, T-bill	Y
		VAR: GDP, deflator, *commodity prices*, T-bill	N
		GMM: Greenbook forecasts of GDP and deflator, T-bill futures	Y
Balke and Emery (1994)	1960-1993	VAR: GDP, deflator, fed rate,NR,TR	Y
		VAR: GDP, deflator, *com prices*, fed rate,NR,TR	N
Giordani (2004)	1966q1-2001q3	VAR: GDP, inflation, fed rate	Y
		VAR: Gap, inflation, fed rate	N
Hanson (2004)	1959:1-1998:12	VAR: IP, CPI, fed rate	Y
Bernanke et al. (2005)	1959:1-2001:8	VAR: IP, CPI, fed rate	Y
		FAVAR	N
Romer and Romer (1994)	1969:1-1996:12	VAR: IP, PPI, fed rate	Y
		VAR: IP, PPI, *com prices*, fed rate	N
		VAR: IP, PPI, new measure	N
Barth and Ramey (2002)	1959:2-2000:3	VAR: IP, price level, com prices, M2, fed rate	N
Rabanal (2007)	1959:1-2004:4	VAR: non-farm business sector output, deflator, fed rate	Y

Table 3 United States, post-1982 period

Author	sample period	methodology and variables	price puzzle?
Balke and Emery (1994)	1983-1993	VAR: GDP, deflator, fed rate,NR,TR	Y (not signif.)
	1982-1993	VAR: GDP, deflator, *com prices*, fed rate,NR,TR	N
Boivin and Giannoni (2006)	1984q1-2001q2	VAR: GDP, inflation, *com prices*, fed rate	N (output puzzle!)
		FAVAR	N
Hanson (2004)	1982:11-1998:12	VAR: IP, CPI, fed rate	Y (not signif.)
Barth and Ramey (2002)	1983:1-2000:3	VAR: IP, price level, *com prices*, M2, fed rate	N (Y first5m)
Milcheva (2013)	1987:q1-2008:q1	VAR: inflation, GDP, the fed rate, house prices, mortgage mix	Y
	1987:q1-2008:q1	VAR: inflation, GDP, the fed rate, house prices, mortgage mix,*com prices*	Y

variables in the VAR proves, most of the time, useless. If one considers the whole extended period there is a price puzzle that, however, can be "cured" adding variables that improve the specification. Finally, focusing just on the post-1982 period, the results for the whole period are confirmed but both the variables reaction to the monetary shock and the price puzzle become weaker. Hence, the consequences of including any information variable vary over the sample period considered: the sample period and the monetary regime seem to be crucial elements in the understanding of this anomalous response of prices.

2.1 US and the Euro area: a comparison

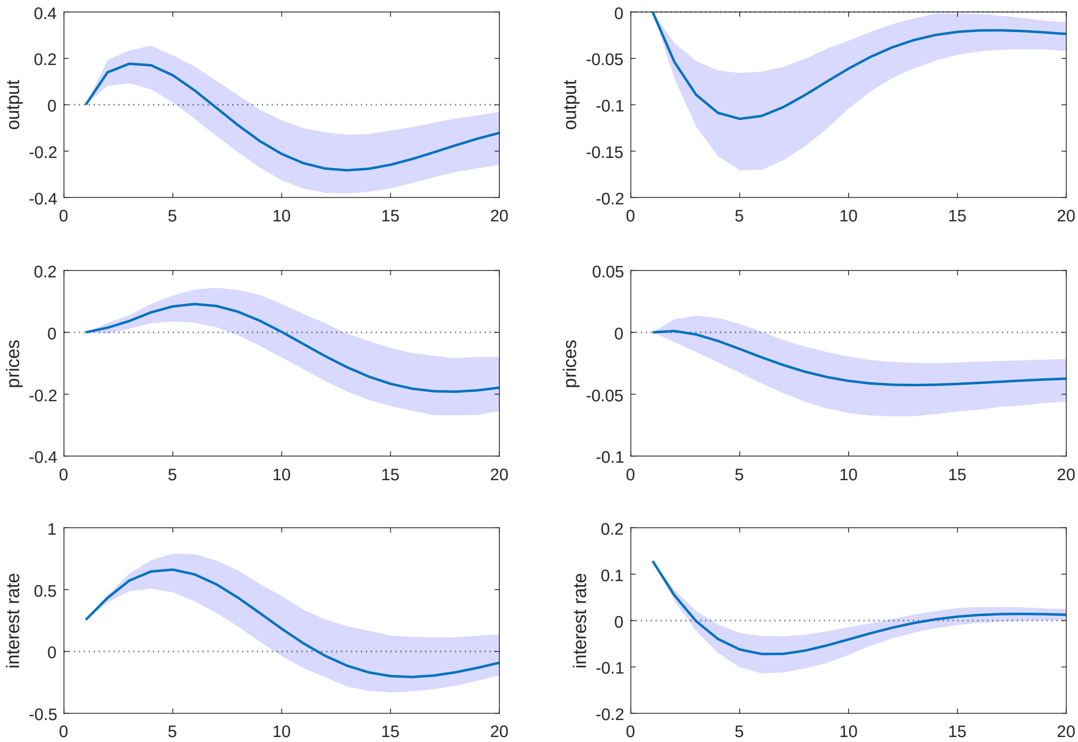
In this section we want to focus our attention on the years up to the start of the Great Recession. To the end of comparison, we undertake the same empirical analysis both for the United States and for the Euro area under the European Monetary Union (EMU) to disentangle any puzzling response following a monetary tightening. We construct a VAR that contains, for both countries, the following variables: the (log of) real GDP (Y), (the log of) the GDP deflator (P) and the policy rate (R) (the federal funds rate for the Fed and the money market rate for the ECB)[5]. The monetary policy shock is identified employing the Cholesky decomposition where we place the nominal interest rate last in the ordering so that monetary policy reacts to contemporaneous values of the other macroeconomic variables while these are not affected by monetary policy. The sample period goes from the start of the EMU to the start date of the Great Recession for each country. Figure 1 shows the VAR impulse responses for both the United States (1999q1-2007q4) and the Euro Area (1999q1-2008q2).

While there are not puzzling responses in the Euro case, the US case shows both an output and a price puzzle. Moved by this evidence we put forth a tentative explanation for this difference that we will discuss deeply in Section 3 (while Section 4 will be devoted to validate this explanation broadening the number of analysed countries).

According to the usual interpretation, the above results should point to a misspecification problem in the Fed reaction function but not in the ECB one. That is, the simple 3-variables VAR is adequate to correctly describe the effects of monetary shocks in the Euro area but not in the United States. If the missing variable, as previous literature maintains, deals with inflation expectations then (a proxy for) this variable should be added into the VAR for the U.S. but it is not necessary for the Euro area specification.[6] This is not to say that the ECB does not care of private sector's inflation expectations when deciding its policy. Rather, we argue that the ECB, having managed in those years to anchor inflation expectations more firmly than the Fed, has made their presence in the VAR redundant. The price variable in the VAR is itself a sufficient statistics if expectations are well anchored. It can not be denied that both these central banks underwent in those years improvements in managing market expectations and credibility through greater transparency but, as Blinder et al. (2008) admit, talking about central bank transparency, "the Fed is more of a laggard than a leader in this regard" and again

[5] All the variables included are in levels. Note, however, that the key properties of the impulse response functions to a monetary policy shock are insensitive to a growth rate specification. See on this point Christiano et al. (2005). See Appendix A for a description of the dataset and methodology details.

[6] See note 12 for our results from this exercise.



(a) USA 1999q1-2007q4

(b) Euro Area 1999q1-2008q2

Figure 1: IRFs to a Monetary Policy Shock

"the ECB has been more transparent than the Fed ever since it opened its doors in 1998."

The greater transparency achieved by the ECB, if compared to the Fed, allowed to anchor more firmly private expectations in the Euro area.[7] Beechey et al. (2011) support this result comparing the evolution of long-run inflation expectations in the two countries. They find a low and declining disagreement about long run inflation outcomes in the Euro area but not in the United States. Furthermore, while inflation compensation (a proxy for inflation expectations) displays systematic sensitivity to current news in the U. S., it does not in the euro area. This evidence brings the authors to support the view that long-run inflation expectations were not firmly anchored in the U.S. as in the euro area.

3 The role of inflation expectations

Many authors have argued that inflation expectations in the United States were not anchored before Volcker tenure because the Federal Reserve did not follow the so called Taylor principle.[8] Empirical analyses for those years uncover a smaller than one coefficient for inflation in a Taylor rule, that is to say that the central bank moved the nominal interest rate less than one-to-one in response to variations in inflation. According to these authors such an accommodative behavior has been responsible for inflation getting out of control in the Seventies. Belaygorod and Dueker (2009) claim that the price puzzle is not "necessarily a false finding that pertains only to mis-specified VARs" but, rather, it could be a genuine phenomenon in the presence of a monetary policy behaviour that induces indeterminacy, as it happens in the seventies in the United States.

However, the accommodative behaviour by the central bank or, in Leeper's (1991) terminology, a passive central bank, would be consistent both with an indeterminate regime, in case of a passive fiscal authority, or with a determinate regime if fiscal policy is instead active. In the first case, indeterminacy would lead to instability and self-fulfilling inflation; in the second case, the fiscal theory of the price level holds and, as Leeper and Leith (2016) claim, in this case there is nothing puzzling in a jump of the price level after a monetary tightening.[9]

Announcing a numerical inflation target, instead, should be of help in anchoring long-run inflation expectations[10]. A number of studies shows that inflation targeting (henceforth IT) adopters have succeeded in this task. According to Gurkaynak et al. (2005), for example, forward rates at long horizons react significantly to macro and monetary policy surprises in the 1990-2002 period in the United States. This sensitivity of long rates is taken as evidence of the lack of strongly anchored long-run inflation expectations in that country which, until 2012, did not possess an explicit inflation target.[11] Gurkaynak et al. (2010) get similar evidence for the United Kingdom before 1997, when the Bank of England was not independent, but not after that date. A finding that

[7] Some ascribe this success to the fact that the ECB provided a numerical definition of price stability that, instead, the Fed introduced later in 2012.

[8] See Clarida et al. (2000) and Boivin and Giannoni (2006).

[9] Under the fiscal theory of the price level, an increase in the nominal interest rate raises the market value of debt and households' interest receipts. The resulting wealth effects, not offset by the government that undertakes an active fiscal policy, raise the price level.

[10] See Blinder et al. (2008).

[11] A plausible explanation, the authors suggest, could be changes in the private sector's perception of the inflation target.

signals that long run inflation expectations are more firmly anchored in the presence of an explicit and credible inflation target. The same results for Sweden in the period following the inflation targeting adoption confirm this view.

Levin et al. (2004) find that IT has anchored inflation expectations, since expectations appear successfully de-linked from realized inflation, while, at the mean time, it reduced inflation persistence. On this last point, Benati (2008) looks first at statistical persistence - that is, inflation serial correlation - and then at structural persistence, by estimating if the indexation parameter in New Keynesian Phillips curve varies across different regimes. As for the statistical persistence, he documents a negative serial correlation for United Kingdom inflation and its white noisiness for IT countries (Canada, New Zealand and Sweden), together with its absence in the Euro zone under EMU and for Switzerlnd in the new Swiss monetary regime. The absence of statistical persistence is confirmed also under the gold standard for U.S., U.K. and Sweden. The indexation parameter turns out to be very low or zero under stable regimes with clearly defined nominal anchors, pointing to a purely forward looking inflationary process. In particular, while he found inflation persistence to have vanished in countries where expectations had been anchored, this did not happen in countries, like U.S. and Japan, that, at the time, lacked any such anchor.

The above analysis confirms that inflation behavior and the anchoring of its expectations are tightly linked processes. We exploit this link to seek if the presence of a price puzzle can be consistent with unanchored expectations. Before turning to this empirical evidence, we devote the next subsection to review how anchored, contained and unmoored expectations have been defined in the literature.

3.1 Unmoored, contained, anchored expectations and the price puzzle

The importance of managing market expectations to the conduct of monetary policy is largely acknowledged. This is why the central bank in its communication often refers to the status of market expectations. In FOMC minutes one can read that inflation expectations are thought to be contained rather than anchored and, at specific events or sample periods, they have happened to be unanchored or unmoored. Building on Bernanke's (2007) notion of anchored expectations, Carvalho et al. (2017), claim that inflation expectations are anchored when agents' long run inflation beliefs are relatively insensitive to surprise movements in contemporaneous inflation, whereas when they display elevated sensitivity to new information they are poorly anchored.

Potter and Rosenberg (2017) provide the following definitions of anchored, contained and unmoored expectations. If the underlying inflation process driving expectations is quickly attracted to its long-run average, then we face anchored expectations and the public has confidence that inflation will remain low in the long run. On the other hand, if the same process is nonlinear and characterised by a quick attraction to bounds around the long-run mean but a slow movement toward its long-run average within the bounds, expectations are contained. There are, instead, unmoored expectations when these are neither quickly attracted to the long-run mean or bounds. Which are the consequences on the price puzzle of each of these different degree of expectations anchoring? And, further, which countries or sample periods can be associated, in turn, with each of them? Let's start with anchored expectations.

According to Demertzis et al. (2010), if a central bank correctly anchors expectations then, long run inflation expectations will be decoupled from short run inflation dynamics. In particular, a credible inflation expectations disconnect would imply: (a) the anchoring of inflation expectations to a constant average; (b) a decreasing persistence of actual inflation as credibility increases; (c) the absence of Granger causality between expected and actual inflation; (d) no contemporaneous transmission of shocks from actual to expected inflation and vice versa. In this event, if the central bank cares about price stability and takes into account inflation expectations in its decision process, a VAR including just [yt, pt, it] would be correctly specified and would not produce any price puzzle. In fact, being inflation expectations anchored to a constant average (from (a))- usually at the inflation target announced by the monetary authority- and not explaining neither affecting actual inflation (from (c) and (d)), inflation expectations would be redundant once effective inflation has been included in the VAR as a policy decision variable. This, according to Section 2, seems to be the case for the Euro area under EMU. Do IT adopting countries, that have firmly anchored inflation expectations, show puzzling responses of economic variables to a monetary shock when a simple 3-variable VAR is employed? We will cope with this analysis in the next section.

Although the central bank takes seriously into account private sector inflation expectations in making policy, these could happen to be just contained (rather than fully anchored). In this case inflation expectations have itself an informational value for the conduct of monetary policy, given the absence of a disconnect between actual inflation and long term inflation expectations over a period of lower credibility (Demertzis et al., 2010). Therefore a VAR including just [yt, pt, it] would not be correctly specified since it would not contain inflation expectations the central bank reacts to that, in turn, affect and help explaining actual inflation. This circumstance would produce a price puzzle. Such seems to be the case for U.S. policy starting from Volcker disinflation: according to Potter and Rosenberg (2017), in the United States there was strong evidence for inflation expectations being just contained before the Great Recession.

With the end of the Great Inflation, in the mid-eighties, the economy was confronted with fewer shocks. Monetary policy became more systematic and it responded more decisively to fluctuations in economic conditions. The R-squared associated to the central bank reaction function was larger and economic variables responded less to monetary disturbances (Boivin and Giannoni, 2006). In those circumstances it was easier for the public to understand central bank movements and, in turn, it became also easier for the monetary authority to manage market expectations thus to anchor or, at least, to contain them.

On the other hand, if the central bank does not seek to anchor inflation expectations, a VAR that includes just [yt, pt, it] could be correctly specified and, in this case, the subsequent price puzzle might not be "a puzzle" but just the result of different dynamics of the economy. This seems the case for the U.S. during the Great Inflation, from 1965 to 1979, when the inclusion of a proxy for inflation expectations or controlling for endogeneity and/or anticipatory actions does not solve the puzzle. For example, as we stressed before, the dynamics of the price level when the fiscal theory of the price level holds would be entirely consistent with the price puzzle.[12]

4 Is there a price puzzle in the IT countries?

We now want to check if countries that have firmly anchored inflation expectations show puzzling responses of economic variables, in particular prices, to monetary policy shocks. To this end we employ again the 3 variable VAR used for the previous comparison between the United States and the Euro area.[13] Six more countries are now considered: United Kingdom, Canada, Sweden, and New Zealand which have adopted IT; Switzerland whose Swiss National Bank provided in those years a quantitative definition of price stability (as ECB does) and Japan which was nor an inflation targeter neither provided a definition of price stability (as the United States) before the Great Recession.[14]

We study two different sample periods for each country that correspond to a pre- and post-IT regime. The regimes are identified following Benati (2008).[15] Our sample differs from Benati's in two aspects. First, we fix the beginning of the IT regime, for each country, three quarters after its formal introduction: this increases our confidence about its effective operation. Second, we extend our dataset to the years just before the Great Recession: the second regime ends at the date indicated by the OECD based recession indicator as the starting date of the Great Recession for each country.

Figure 2 reports the response of the non-policy variable to a one standard deviation innovation (corresponding to a positive shock) in the policy variable. The solid lines depict the estimated median responses, while the grey bands are the 16%-84% percentile bands. Note that the choice of a relatively narrow probability band serves our purpose to show that the price puzzle effectively disappears when the central bank adopts the inflation targeting approach.

Comparing the two regimes for each country, one can realise that the price puzzle always appears in the first period while it fades away in the more recent, inflation-anchored regime. This result holds for all countries except for Japan that lacked any anchor to stabilize inflation expectations and which shows a price puzzle in both periods.

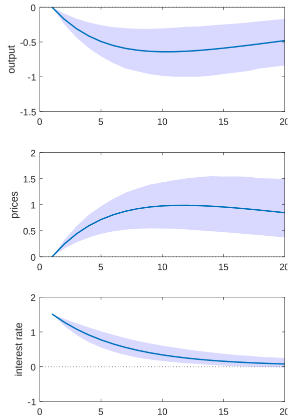
In the more recent period of lower inflation persistence and more anchored expectations the price puzzle seems to dissipate in those countries where IT has been adopted or where a numerical measure of price stability is provided to the public (including the Euro area, see Figure 1) but not in those countries (as Japan or the

[12] According to our estimates, even the period 1999-2007 shares the same characteristics. When we introduce (the log of) a commodity price index in the VAR for the United States for this period, the price puzzle does not disappear. This would be consistent with the finding by Milcheva (2013) and even with Davig and Leeper (2011) who claim: "The joint policy process throughout much of the 2000s has been passive monetary policy and active fiscal policy". Results are available from the author upon request.

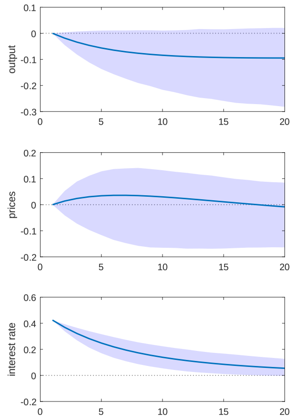
[13] See Appendix A for data description and methodological details.

[14] While in the United States an explicit 2% inflation target was introduced in January 2012, in Japan it was introduced a year later.

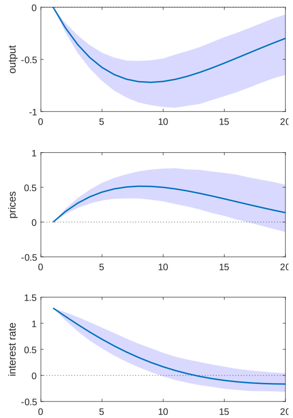
[15] See Benati (2008)'s Appendix 2. Due to data availability, for New Zealand we look just at the post-IT regime.



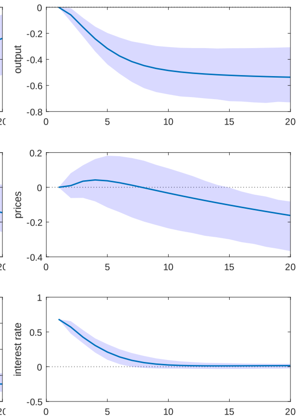
(a) UK 1972q3-1992q3



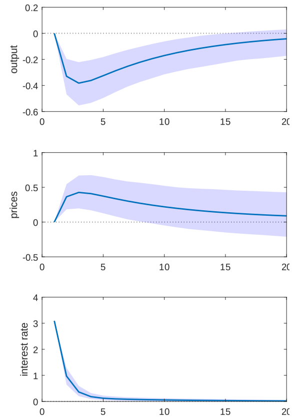
(b) UK 1993q3-2007q4



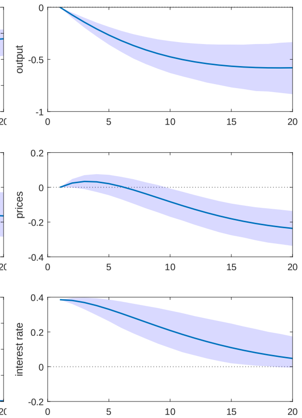
(c) Canada 1971q3-1990q4



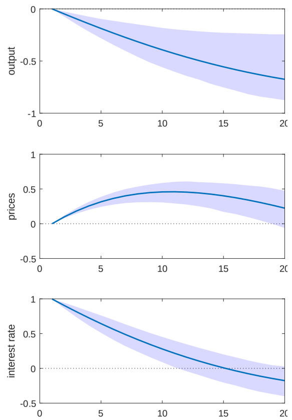
(d) Canada 1991q4-2007q2



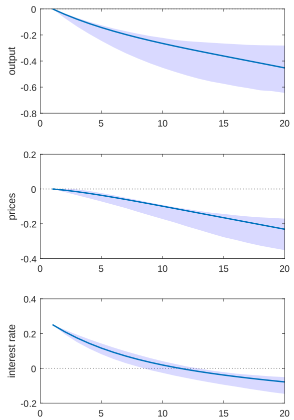
(e) Sweden 1971q3-1992q4



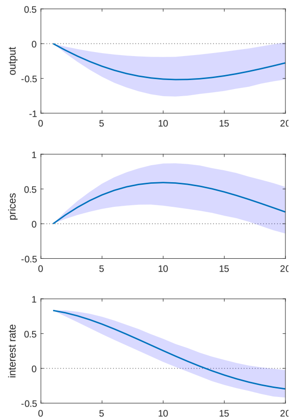
(f) Sweden 1995q1-2007q3



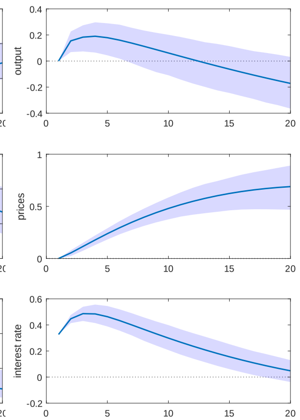
(g) Switz. 1975q4-1999q4



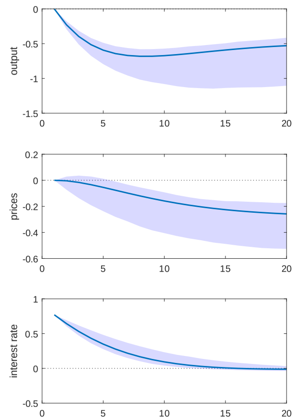
(h) Switz. 2004q1-2008q1



(i) Japan 1971q3-1982q4



(j) Japan 1983q1-2007q4



(k) NewZea 1990q4-2007q2

Figure 2: IRFs to a Monetary Policy Shock

United States) where expectations were, at that time, just contained or even unmoored.

5 Anchored expectations and the cost channel: what evidence for the price puzzle?

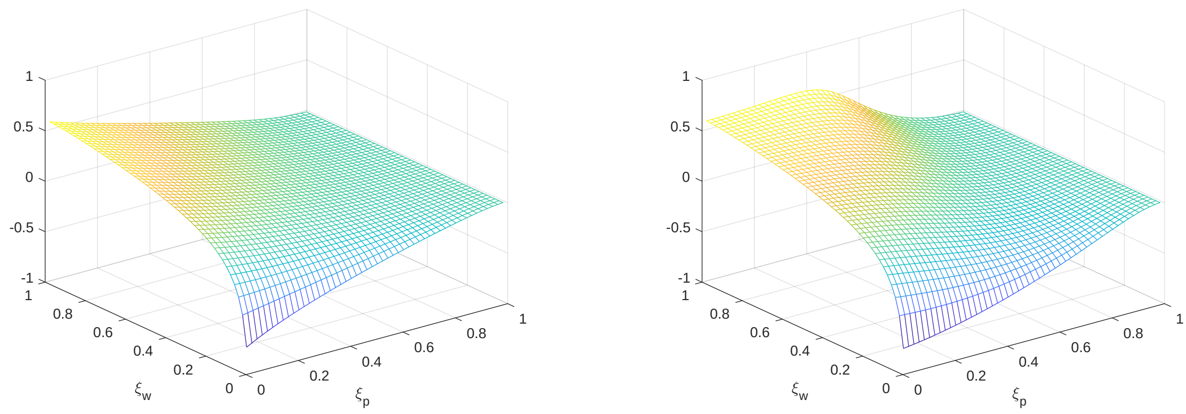
Till now we have disregarded an alternative theoretical explanation for the price puzzle: the presence of a cost channel of monetary policy. If firms must pay wage-bills to workers before receiving their revenues from sales, they depend on credit to finance these payments. In this case, the interest rate charged from the financial intermediary on the borrowed funds will enter into the firm's real marginal costs. This causes prices and nominal interest rates to move in the same direction after a monetary policy shock. After a monetary policy tightening the interest rate increase by the central bank raises borrowing costs and, as a result, inflation soars. If this "supply side" effect happens to dominate the "demand side" traditional liquidity effect, the price puzzle emerges.

Barth and Ramey (2002) look for evidence of a cost channel employing a VAR analysis. Comparing the pre-Volcker period (1959:2-1979:9) to the Volcker Greenspan one (1983:1-2000:3), they find that while the first sample shows very strong cost-channel effects, the same effects are much weaker in the most recent sample. Among the possible explanations put forward by the authors: the existence of alternative sources of funds available in the later period to banks and firms, the absence in the later period of monetary tightening accompanied by restrictive credit actions undertaken by the monetary authority, together with some considerations about the changing exchange rate regime. According to them, the rise in prices following a monetary contraction is not a puzzle if there is a cost channel at work, as they find in the pre-Volcker period.

We now want to check how the anchoring of expectations (that leads, according to Benati (2008) to an entirely forward looking Phillips curve) would interact with the price puzzle result in the presence of a cost channel. To this end, we employ the model by Christiano et al. (2005) that includes a working capital assumption.[16] In this model the presence of a cost channel is a necessary (though not sufficient) condition to have a price puzzle and, actually, the model simulations deliver always such a perverse dynamic when the authors' (key) benchmark parameters are used.

As already stressed, Benati (2008) finds that the anchoring of expectations comes with a reduction in trend inflation and in the practice of indexation. This view is even supported by Hofmann et al. (2012) according to whom, thanks to improved monetary policy, the anchoring of inflation expectations has reduced inflation uncertainty and has lead to lower wage indexation as well as contained second-round effects. Their analysis confirms Benati's view that indexation is not structural in the sense of Lucas (1976). However, Ball et al. (1988) recognised, as a robust finding from their analysis, a direct relationship between average inflation and price flexibility. With staggered contracts, they maintain, a higher rate of inflation makes prices go out of line more rapidly and this increases the frequency of price changes. Therefore prices should be less flexible when

[16] Since this model is well known in the literature, we report in Appendix B only the log-linearized equations of the model.



(a) hybrid Phillips curve

(b) forward looking Phillips curve

Figure 3: Impact price change to a Monetary Policy Shock

inflation is low and stable. Fernandez-Villaverde and Rubio-Ramirez (2007) confirm this result through their empirical analysis for the United States. They find that times of decreasing trend inflation (the 80's and the 90's) are times of increasing average duration of prices: starting form the mid-eighties price rigidity increases[17]. Supported by these results we agree with Benati (2008) that "it is difficult to believe that the frequency of price adjustment may remain unchanged in the face of movements in the low-frequency component of inflation." (p.1045). In other words, as well as indexation parameters, even Calvo parameters should not be considered structural.

Under this perspective, that is, allowing Calvo parameters to change, which implications could be gauged employing the Christiano et al. (2005) model as the price puzzle result is concerned? In the presence of a cost channel, is there always a price puzzle result when Calvo parameters change? And, what happens when, given the anchoring of expectations, the traditional Phillips curve is replaced by an entirely forward looking one?

Figure 3 shows, in a three dimensional space, the response of prices (on the z-axis) as the Calvo parameters of wage and price rigidity (on the x and y-axis) change when a traditional hybrid Phillips curve is considered. Figure 4, instead, delivers the output of the same exercise when the hybrid Phillips curve, obtained thanks to a dynamic indexation scheme, is replaced with an entirely forward looking one - in place when a static indexation scheme is instead employed. As both figures show, the presence of a price puzzle is contingent to the degree of rigidity in prices and wages. In particular, irrespective of the degree of wage rigidity, if price rigidity is high (say, larger than 0.8) a contractionary monetary policy shock never makes prices increase. On the other hand, the more flexible prices become, the higher is the degree of wage flexibility required to avoid a price puzzle. To sum up, we find that the price puzzle is absent when price rigidity is larger than wage rigidity. If, on the other hand, prices are flexible and wages are rigid a large price puzzle emerges. This evidence holds under the two different specifications of the Phillips curve employed. Going from an hybrid Phillips curve to an entirely

[17]They also find that periods of high price rigidities are associated to low indexation.

forward looking one affects the amplitude of the response of prices but not its sign. The only effect is to amplify the price puzzle result when wage rigidity is larger than price rigidity and to further reduce the response of prices after a contractionary monetary policy shock when price rigidity prevails[18].

This result is consistent with previous works on the argument but, at the same time, adds up to new evidence. While we study how the responsiveness of price changes for different values of both price and wage Calvo parameters, Rabanal (2007) shuts down each of them one at a time (keeping the other fixed at its benchmark value). He points out that, among the features necessary to make the demand effects prevail and inflation fall after a monetary contraction, beside a low degree of wage indexation, a high degree of price stickiness is needed together with a low degree of wage stickiness[19]. According to our results, if the anchoring of inflation expectations, decreasing inflation persistence, induces, as it should, a minor need to change prices, then the price puzzle is avoided even when a cost channel is at work. It could suffice an high amount of price rigidity to get the result, irrespective of the degree of wage rigidity.

After the Great Moderation price rigidity seems higher not only in absolute terms but even relative to wage rigidity. Fernandez-Villaverde and Rubio-Ramirez (2007) find that, starting from the nineties with inflation going down, wage rigidity goes down too. Furthermore, comparing HP-trend price and wage rigidity, they give evidence of the fact that starting from the mid eighties, thus with the start of the Great Moderation, in the United States price rigidity is always larger than wage rigidity and while the first shows an upward trend, the second shows a downward one. Ever for other countries empirical evidence points to greater price than wage rigidity, at least starting from the eighties. This is the case for United Kingdom analysed by DiCecio and Nelson (2007) for the post 1979 period, who claim that an emphasis on price, rather than wage, stickiness is appropriate in analyzing this country. As for the Euro area, Smets and Wouters (2003) claim that a very robust outcome of their estimated model for Europe, considering the sample period 1980-1999, is larger price (with a Calvo parameter of 0.908) than wage rigidity (0.737). Also Christoffel et al. (2008), estimating the same parameters for the same area for a subsequent period (1985-2006), find a very high price rigidity (0.92)[20], higher than wage one (0.765).

Therefore it is entirely possible that the anchoring of inflation expectations and a lower inflation persistence change not only indexation but even Calvo parameters. That is to say, both indexation parameters and Calvo parameters of price and wage rigidity are not invariant across monetary policy regimes and cannot be considered structural in the sense of Lucas (1976). In this case, with the anchoring of inflation expectations, the price puzzle would be avoided even when a cost channel is at work.

[18] Christiano et al. (2005) find that when the model is re-estimated under an entirely forward looking Phillips curve it gives a higher price stickiness (0.72 in place of 0.6) and a lower wage stickiness (0.49 instead of 0.64): a situation that, according to our results, would not deliver any price puzzle.

[19] All features he finds to prevail when he estimates the DSGE model.

[20] Conducting recursive estimates over the years 1998-2006 they find it gradually rising.

6 Conclusions

This paper discusses the puzzling response of prices after a monetary tightening delivered by a VAR. Since the bulk of empirical studies on the argument focuses on U.S. evidence, we have first tried to disentangle empirical regularities surveying the papers that deal, directly or indirectly, with the price puzzle in this country. We find that the price puzzle result is affected by the state of inflation expectations as well as by the monetary regime in place.

During the Great Inflation, with the central bank loosing control over prices, indexation and second round effects prevail, making the price puzzle an empirical regularity. This result is due, we maintain, to the unmoored state of market expectations. During the Great Moderation, instead, the disappearance of the price puzzle, if inflation expectations are someway included in the VAR, would signal both that these are necessary (policy) variables in the Fed decision process but also that the inclusion of the sole effective inflation rate is not sufficient. If inflation expectations provide better information to the central bank, not included in the effective inflation rate, then inflation expectations, although not unmoored, can be considered as contained. This view is supported by empirical evidence from the literature showing that U.S. inflation expectations during that period appear contained rather than anchored. Our empirical analysis for the more recent period that includes the pre-Great Recession years shows again a price puzzle. Furthermore, including a commodity price index does not solve the puzzle. This result, that deserves further investigation, could be consistent with a passive monetary/active fiscal mix prevailing in that period.

We check if countries that adopted IT, or with well-anchored inflation expectations, show a price puzzle. In the countries analysed, without including any proxy for inflation expectations, we do not find such a perverse dynamic. We conclude that countries characterised by clearly defined nominal anchors, having anchored inflation expectations, have managed to rule out the persistent increase in the price level.

Finally, we explore another well-known explanation for the price puzzle result: the presence of a cost channel. Employing a standard DSGE model, we find that the presence of a price puzzle is contingent to the degree of rigidity of prices and wages. The amplitude of the price response, instead, varies with the anchoring of expectations. The price puzzle is absent for high values of price rigidity (say, for a Calvo price parameter higher than 0.8) or whenever price rigidity is larger than wage rigidity.

The anchoring of expectations, making inflation low and less persistent (Benati, 2008), contributes to increase price rigidity (Ball et al., 1988) and this makes the price puzzle disappear. Furthermore, many countries seem characterised by higher price than wage rigidities when the more recent period is considered. A result that, again, would make the price puzzle disappear even in the presence of a cost channel.

7 Appendix A

We construct a VAR that contains: the (log of) real GDP (Y), (the log of) the GDP deflator (P) and the policy rate (R). Whenever the policy rate was not available, we replaced it with a money market interest rate. Results are robust to different choices of short-term rates. The monetary policy shock is identified employing the Cholesky decomposition where we place the nominal interest rate last in the ordering so that monetary policy reacts to contemporaneous values of the other macroeconomic variables while these are not affected by monetary policy. The solid lines in Figures 1 and 2 depict the estimated median responses to a one-standard deviation monetary policy shock, while the grey bands are the 16%-84% percentile bands. If not otherwise stated, one lag has been employed.

Euro Area

Sample period: from the start of the EMU to the start date of the Great Recession, 1999Q1 to 2008Q2.

Data: Real GDP is reference chained, seasonally adjusted, domestic currency; source: IMF-IFS. GDP deflator is seasonally adjusted; source: IMF-IFS. The interest rate is the money market interest rate, Percent per annum; source: IMF-IFS.

United States

Sample period: from the start of the EMU to the start date of the Great Recession, 1999Q1-2007Q4.

Data: Real GDP is Billions of Chained 2009 Dollars, Quarterly, Seasonally Adjusted Annual Rate [GDPC1]; source: U.S. Bureau of Economic Analysis. GDP Deflator is Implicit Price Deflator, Index 2009=100, Quarterly, Seasonally Adjusted [GDPDEF]; source: U.S. Bureau of Economic Analysis. The interest rate is the Federal Funds Effective Rate (% P.A.), Selected Interest Rates (H.15) [FFO]; souce: U.S. Board of Governors of the Federal Reserve System. The commodity price index is the Producer Price Index (PPI) - Commodity Series [WPU03THRU15]: Industrial Commodities, (Index 1982=100, NSA); source: U.S. Bureau of Labor Statistics (BLS).

Lags: two.

United Kingdom

First sample period: from June 23, 1972 to the introduction of inflation targeting (on October 8, 1992), 1972q3-1992q3.

Data: Real GDP is at Market Prices in the United Kingdom, Millions of Chained 2013 British Pounds, Quarterly, Seasonally Adjusted [GDPC1]; source: U.S. Bureau of Economic Analysis. Nominal GDP is at Market Prices in the United Kingdom, Millions of British Pounds, Quarterly, Seasonally Adjusted [NGDPMPUKQ]; souce: Bank of England. GDP Deflator is obtained by dividing the nomial GDP by the real GDP. The interest rate is the Money Market Interest rate, Percent per annum; souce: IMF-IFS.

Second sample period: from the IT regime to the start of the Great recession, 1993q3-2007q4.

Data: Real GDP isMillions of Chained 2010 National Currency, Quarterly, Seasonally Adjusted CLVMNAC-

SCAB1GQUK; source: Eurostat. GDP Deflator is Implicit Price Deflator in United Kingdom, Index 2010=100, Quarterly, Seasonally Adjusted [GBRGDPDEFQISMEI]; source: OCSE. The interest rate: see before.

Canada

Sample period: the first sample goes from the collapse of Bretton Woods to the introduction of IT (February 26, 1991), 1971q3-1990q4. The second from the IT regime to the start of the Great Recession, 1991q4-2007q2.
Data: Real GDP [CNOEXO03D], source: OECD, Quarterly national account. Nominal GDP [CNOEXA03B], source: OECD. GDP Deflator is obtained by dividing the nominal GDP by the real GDP. The interest rate is the immediate Rate, less than 24 hours: Central Bank Rates for Canada, Percent, Quarterly, Not Seasonally Adjusted [IRSTCB01CAQ156N], source: Board of Governors of the Federal Reserve System. When the money market rate by the IMF-IFS is used results are unchanged.
Lags: two in the second sample.

Sweden

Sample period: the first sample goes from the collapse of Bretton Woods to the introduction of IT (on January 15, 1993), 1971q3-1992q4. While the IT regime was announced in 1993, it was put into practice in 1995. We take this date as the beginning of the second regime that ends at the start of the Great Recession, 1995q1-2007q3.
Data: Real GDP [SWOEXO03D], source: OECD, Quarterly national account. Nominal GDP [SWOEXA03B], source: OECD. GDP Deflator is obtained by dividing the nomial GDP by the real GDP. The interest rate is the money market rate [SWQ60B..], source: IMF-IFS.

New Zealand

Sample period: since we lack data for New Zealand pre-1990, we look just at one sample from IT (which was introduced on February 1, 1990) to the start of the Great recession, 1990q4-2007q2.
Data: Real GDP is Total GDP, National Currency, Quarterly, Seasonally Adjusted [NAEXKP01NZQ189S], source: OECD. Nominal GDP is Current Price GDP, Billions of New Zealand Dollars, Quarterly, Seasonally Adjusted [NZLGDPNQDSMEI], source: OECD. GDP Deflator is obtained by dividing the nomial GDP by the real GDP. The interest rate is the Money Market rate, Percent per annum, source: IMF-IFS.

Switzerland

Sample period: the first goes from the collapse of Bretton Woods to the introduction of the new "monetary policy concept" (on January 1, 2000), 1975q4-1999q4. The second goes from the post-2000 regime to the start of the Great Recession, 2000q4-2008q1.
Data: Real GDP [SWOEXO03D], source: OECD, Quarterly national account. Nominal GDP [SWOEXA03B], source: OECD. GDP Deflator is obtained by dividing the nominal GDP by the real GDP. The interest rate is the money market rate [SWQ60B..], source: IMF-IFS.

Japan

Sample period: the first sample is the post- Bretton Woods period, 1971q3-1982q4. The second ranges from the post-Great Inflation episode (set to January 1983) to the start of the Great Recession, 1983q1-2007q4.

Data: Real GDP [JPOEXO03D], source: OECD, Quarterly national account. Nominal GDP [JPOEXA03B], source: OECD. GDP Deflator is obtained by dividing the nominal GDP by the real GDP. The interest rate is the money market rate [JPQ60B..], source: IMF-IFS.

Lags: two in the second sample.

8 Appendix B

This appendix describes the linearised system in Christiano et al. (2005). For convenience, model parameters and variables are summarized in Table 4.

The model incorporates both nominal frictions (sticky prices and wages) and dynamics in preferences and production (habit formation in consumption, investment adjustment costs, and variable capital utilization). Prices and wages are fixed according to Calvo (1983); firms not allowed to reoptimize their pricing and wage decision index them to the previous period's inflation. As in the model by Calvo (1983), a firm can only reoptimize the nominal price with probability (1-ξ_p). In this case, the firm reoptimzes before the monetary policy shock realization. If it can not reoptimize, and this happens with probability ξ_p, prices are just indexed to lagged inflation: $P_{jt} = \pi_{t-1}P_{j,t-1}$ with $\pi_t = P_t/P_{t-1}$. This specification is called "dynamic" to distinguish it from the "static" price-updating scheme that, instead, indexes prices not to past inflation but to the steady state gross rate of inflation ($\bar{\pi}$): $P_{j,t} = \bar{\pi}P_{j,t-1}$. As a consequence, in this model, ξ_p signals the degree of price stickiness.

The implied inflation dynamics are given by the following Phillips curve:

$$\widehat{\pi}_t = \frac{1}{1+\beta}\widehat{\pi}_{t-1} + \frac{\beta}{1+\beta}E_{t-1}\widehat{\pi}_{t+1} + \frac{(1-\beta\xi_p)(1-\xi_p)}{(1+\beta)\xi_p}E_{t-1}\widehat{s}_t \tag{B1}$$

with the real marginal cost $\widehat{s}_t$ given by:

$$\widehat{s}_t = \alpha\widehat{r}_t^k + (1-\alpha)\widehat{w}_t \tag{B2}$$

where hats on variables indicate the log-deviations from steady-state values. This is an hybrid new Keynesian Phillips curve since it contains, beside a forward looking term for inflation, even a backward looking one due to the presence of dynamic indexation that introduce, in a rather ad hoc way, the greater persistence in inflation usually found in the data. Whenever the other (static) form of indexation were used, the above equation would reduce to the following:

$$\hat{\pi}_t = \beta E_{t-1}\hat{\pi}_{t+1}\frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p}E_{t-1}\hat{s}_t \tag{B1bis}$$

where current inflation depends just on future inflation.

The nominal wage equation is given by:

$$0 = \widehat{w}_{t-1} - \frac{b_w\left(1+\beta\xi_w^2\right)-\lambda_w}{b_w\xi_w}E_{t-1}\widehat{w}_t + \beta E_{t-1}\widehat{w}_{t+1} + E_{t-1}\left[\beta\left(\widehat{\pi}_{t+1}-\widehat{\pi}_t\right)-\left(\widehat{\pi}_t-\widehat{\pi}_{t-1}\right)\right] + \frac{1-\lambda_w}{b_w\xi_w}E_{t-1}\widehat{\psi}_t - \frac{1-\lambda_w}{b_w\xi_w}E_{t-1}\widehat{L}_t \quad \text{(B3)}$$

Firms' optimality conditions imply that their total payments for capital services equal their total cost of hiring labor each period:

$$\widehat{r}_{t+1}^k = \widehat{w}_{t+1} + \widehat{R}_{t+1} + \widehat{L}_{t+1} - \widehat{K}_{t+1} \qquad (B4)$$

The assumption underlying this condition is that firms finance their wage bill with funds borrowed one period earlier. Real unit labor costs are therefore (in log terms) equal to the sum of the real wage and the short-term nominal interest rate.

The typical household's intertemporal Euler equation for consumption and first-order condition for capital purchases are, respectively,

$$E_t\left\{\widehat{\psi}_{t+1} + \widehat{R}_{t+1} - \widehat{\pi}_{t+1} - \widehat{\psi}_t\right\} = 0 \qquad (B5)$$

$$0 = E_{t-1}\left\{-\widehat{P}_{k',t} - \widehat{\psi}_t + \widehat{\psi}_{t+1} + (1-\beta(1-\delta))\left[\widehat{\bar{w}}_{t+1} - \widehat{\pi}_{t+1} + \widehat{R}_{t+1} + \widehat{L}_{t+1} - \widehat{K}_{t+1}\right] + \beta(1-\delta)\widehat{P}_{k',t+1}\right\} \qquad (B6)$$

Because of habit formation in preferences, the household marginal utility of consumption depends on the current, prior, and expected future levels of consumption:

$$\widehat{H}_t - \chi\widehat{H}_{t-1} - (1-\chi)\widehat{c}_{t-1} = 0 \qquad (B7)$$

$$E_{t-1}\left\{-\beta\chi\widehat{\psi}_{c,t+1} + \sigma_c\left[\widehat{c}_t - \tfrac{b}{1-\chi}\widehat{H}_t\right] - (b+\chi)\beta\sigma_c\left[\widehat{c}_{t+1} - \tfrac{b}{1-\chi}\widehat{H}_{t+1}\right] + \widehat{\psi}_{c,t}\right\} = 0 \qquad (B8)$$

The economy's technology allows additional productive services to be generated, at a cost, from an unchanged stock of physical capital. The degree of capital utilization—that is, the difference between the physical capital stock (denoted by an overbar) and capital services—is chosen by households to equate marginal cost and marginal benefit:

$$E_{t-1}\left[\tfrac{1}{\sigma_a}\widehat{r}_t^k - \widehat{k}_t - \widehat{\bar{k}}_t\right] \qquad (B9)$$

The equilibrium condition for household investment choices can be written as

$$E_{t-1}\widehat{P}_{k',t} = sE_{t-1}\left\{\widehat{i}_t - \widehat{i}_{t-1} - \beta\left[\widehat{i}_{t+1} - \widehat{i}_t\right]\right\} \qquad (B10)$$

This condition indicates that the price firms pay for capital services is a function of two parameters that emerge from the behavior of households: the households' discount factor, β, and the elasticity of their investment adjustment cost function, 1/s.

The stock of physical capital obeys the law of motion:

$$\widehat{\bar{k}}_{t+1} = (1-\delta)\,\widehat{\bar{k}}_t + \delta\widehat{i}_t \qquad (B11)$$

Though physical investment is subject to adjustment costs, this equation indicates that a unit of investment adds to the physical capital stock in a standard manner.

Households' money demand function is given by

$$\widehat{q}_t = \frac{1}{\sigma_q}\left[\frac{R}{R-1}\widehat{R}_t + \widehat{\psi}_t\right] \qquad (B12)$$

a condition that indicates the standard choice between holding money for the transaction services it provides or, instead, holding one-period securities for interest income.

The following identity relates growth of nominal money supply to inflation and changes in real money supply:

$$\widehat{\mu}_{t-1} + \widehat{m}_{t-1} - \widehat{\pi}_t - \widehat{m}_t = 0 \qquad (B13)$$

The (linarization of the) loan market clearing condition is:

$$\mu m(\widehat{\mu}_t + \widehat{m}_t) - q\widehat{\bar{q}}_t - wL\left(\widehat{w}_t + \widehat{L}_t\right) = 0 \qquad (B14)$$

The resource constraint and the aggregate production function can be written as

$$\left(\frac{1}{\beta}+\delta-1\right)\frac{K_y}{C_Y}u + \widehat{c}_t + \delta\left(\frac{K_y}{C_Y}\right)\widehat{i}_t = \left(\frac{\alpha}{C_Y}\right)\widehat{k}_t + \left(\frac{(1-\alpha)}{C_Y}\right)\widehat{L}_t \qquad (B15)$$
$$\widehat{y} = \alpha\widehat{k}_{t-1} + (1-\alpha)\,\widehat{L}_t \qquad (B16)$$

Equation (B15) indicates that resources this period can be consumed, invested, or used to generate additional capital utilization. Equation (B16) indicates that the two inputs in production are labor and capital services.

Monetary policy follows a Taylor rule:

$$\widehat{R}_t = \rho\widehat{R}_{t-1} + (1-\rho)\left(a_\pi E_{t-1}\widehat{\pi}_{t+1} + a_y\widehat{y}_t\right) + \varepsilon_t \qquad (B17)$$

Table 4. Variables and parameter definitions

Variables

$\widehat{\pi}$	inflation
$\widehat{s}$	real marginal cost
$\widehat{\bar{q}}$	transaction money
$\widehat{q}$	real transaction money
$\widehat{R}$	nominal interest rate
$\widehat{m}$	total money supply
$\widehat{\mu}$	money growth rate
$\widehat{\psi}$	marginal utility of consumption
$\widehat{c}$	consumption
$\widehat{\bar{w}}$	wage
$\widehat{w}$	real wage
$\widehat{P}_k$	marginal product of capital
$\widehat{L}$	labor
$\widehat{H}$	habit
$\widehat{\bar{k}}$	capital stock
$\widehat{K}$	capital services
$\widehat{I}$	capital investment
$\widehat{y}$	output
$\widehat{u}$	capacity utilization
$\widehat{r}^k$	return to capital

Parameters

R	steady state nominal interest rate
β	discount rate
α	labor share of production
δ	capital depreciation rate
b_w	simplifying parameter
ξ_p	price stickiness
ξ_w	wage stickiness
λ_w	household labor market power
$\bar{\mu}$	steady state money growth rate
$\bar{m}$	steady state m2
$\bar{q}$	steady state m1
$\bar{w}$	steady state wage
$\bar{L}$	steady state labor supply
b	habit parameter
χ	habit parameter
σ_c	simplifies labor supply decision Euler
σ_a	relates capacity utilization to return on capital
σ_q	relates cash holding and the interest rate
mc	steady state marginal cost (1/markup)
K_Y	steady state capital-output ratio
C_Y	steady state consumption-output ratio
ρ	interest rate smoothing policy parameter
a_π	Taylor rule inflation response
a_y	Taylor rule output response

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