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A FLEXIBLE VIEW ON PRICES

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A flexible view on prices*

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Abstract

This paper argues that the flexible price paradigm is superior to the sticky price paradigm in the context of general equilibrium models. Based on a quarterly data set for six G7 economies, the paper presents two types of evidence showing that prices respond significantly to their underlying fundamentals. First, prices respond contemporaneously and significantly to technology shocks in all countries. Second, the cyclical correlation between prices and unit labor costs is highest contemporaneously and around 0.8 in all cases. This behavior is only consistent with a model where most firms set prices flexibly.

JEL classification: E31; E32

Keywords: Flexible prices; Sticky prices; Inflation; Unit labor costs; Technology shocks

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1 Introduction

An observable feature in any economy is the overall discreteness of price changes. The nature of these dynamics, and its impact on the characterization of business cycles, has been an interest of economists for long. In particular, from the inducted analysis of Hume (1752) to the most recent general equilibrium models, such as Smets and Wouters (2003a), price stickiness has been argued to be a central friction in the monetary policy transmission mechanism.

The prevalence of price stickiness is so embedded in the new neoclassical/ Keynesian literature that the assumption is currently inserted in general equilibrium models like a technology feature of the environment. While in the early 80's the benchmark model was the frictionless real business cycle model of Kydland and Prescott (1982), in the early 00's the benchmark model is a sticky price model, as presented in Goodfriend and King (1997)[1].

The reasoning for this choice is mainly based on empirical evidence. First, the VAR evidence on the effects of monetary policy shocks shows unequivocally that there are significant real effects of monetary policy shocks and that the response of prices is quite protracted. It is well known that a model with flexible prices and no information frictions is not able to reproduce these facts (see Woodford, 2003 for an overview). This observation, coupled with survey evidence showing a staggered behavior of price setting by firms, constitutes solid empirical basis for the sticky price modeling assumption. On a more practical level, the analysis of inflation dynamics requires the modeling of the goods markets, so dealing directly with price stickiness is the simplest way of reconciling theoretical models with the empirical evidence.

The literature has focused on two ways to rationalize the discreteness of price changes by firms. The first is the existence of menu costs: if price changes are costly, there is a zone of price-inaction, where the cost from optimally changing prices is greater than the benefit from that change. The second is the possibility that firms are subject to random shocks that prevent them from observing the true state of nature. This rationalization led Calvo (1983) to assume that firms face an exogenous and constant probability of changing prices. This assumption is the basis of the new-Keynesian forward-looking Phillips curve (see Clarida, Galí and Gertler, 1999).

Several recent contributions have questioned the validity of this new-Keynesian Phillips curve as a good representation of inflation dynamics (see Nason and Smith, 2003, Balakrishnan and López-Salido, 2002, Guay, Luger and Zhu, 2002, Mavroeidis, 2003 and Rudd and Whelan, 2002). In particular, these studies find it difficult to assign a significant role for real marginal costs in the inflation dynamics in several countries, in contrast to what the new-Keynesian theory suggests. Some of these studies also highlight the pitfalls of GMM estimation of the new-Keynesian Phillips curves, namely in properly identifying the respective structural parameters.

This paper evaluates critically the sticky price assumption as a modeling device in general equilibrium models. In contrast with the above studies, our focus does not lie on the estimation of the new-Keynesian Phillips curve. Rather, we will present three sets of evidence suggesting that prices are not intrinsically sticky and are actually quite flexible. First, it will be shown that inflation responds contemporaneously and significantly to a technology shock, in a movement that is incompatible with the existence of significant nominal price-setting rigidities. Second, evidence concerning the cyclical co-movement of prices and marginal costs shall be presented. It will be concluded that the contemporaneous correlation between these series is quite high. Third, several microeconomic studies will be surveyed suggesting that prices are quite flexible in response to changes in the respective fundamentals. Overall, it will be concluded that a flexible price paradigm is more appropriate than a sticky price paradigm in describing the structural frictions underlying the data.

Before presenting this evidence two issues must be stressed: the first is the time unit under consideration; the second is the need to focus on the underlying reasons for a price change. Starting with timing, this is a field where theory has followed the data. Since national accounts are constructed on a quarterly basis, most general equilibrium models are also written and calibrated for that time frequency. This timing is very important for the argument in this paper. Naturally, if the time unit under consideration was a day, most prices would undoubtedly be sticky[2]. In contrast, on a yearly basis, most prices would be considered flexible. In this paper the focus will be exclusively on quarterly data.

The second issue worth underlining relates to the fact that the absence of a price change does not mean *per se* that prices are rigid. This behavior may simply be due to the fact that the price fundamentals have not changed. The absence, in most cases, of data on these two dimensions is one of the most important shortcomings of the microeconomic evidence on price stickiness. The focus of this paper will thus lie on changes in the environment that may trigger a price response by firms.

The rest of the paper is organised as follows. In section 2, the response of several macroeconomic variables to a technology shock in six economies is presented, in particular to uncover the response of inflation to that shock. Section 3 compares, for those economies, the cyclical evolution of prices and marginal costs. Section 4 surveys a number of microeconomic studies that suggest that on a quarterly basis the majority of prices are flexible. Section 5 discusses these results in the context of recent contributions in the dynamic general equilibrium literature. Finally, section 6 contains some concluding remarks.

2 Response of prices to technology shocks

Until recently, the monetary dynamic general equilibrium literature focused to a great extent on the response of the economy to monetary policy shocks. This choice was not related to the importance of these shocks in the developed economies' business cycles. These are patently very small, as can be concluded from numerous contributions, including Altig, Christiano, Eichenbaum and Lindé (2003). Instead, the focus on monetary policy shocks was justified because a consensus has been built over the impact of these shocks on the economy. Following Lucas (1980), if we can write models that can replicate the well-known response of the economy to some shocks, we should be able to use those models as laboratories to answer questions on more complex features of the economy.

An almost consensual outcome in the empirical literature is that after a monetary policy shock there is a protracted response of prices - with or without the so-called price-puzzle - and a hump-shaped response of output (see Christiano, Eichenbaum and Evans, 1999 and 2001)[3]. This prevailing feature led researchers to develop models with sticky prices, which attributed the real effects of monetary policy to the nature of price dynamics.

However, the standard version of these sticky price models failed to "imitate" several features of the data. For example, Chari, Kehoe and McGrattan (2000) show that a sticky price model is not able to generate a sufficiently persistent response of output after a monetary policy shock[4]. As for the response of inflation, the problem with a standard forward-looking version of the Phillips curve is that it implies the front-loading of expected future marginal costs, which produces a jump of inflation on impact. This is at odds with the history-dependence that seems to characterize the data. Only when lagged inflation is included in the inflation dynamics is the sticky-price model successful in replicating the inflation response to a monetary policy shock. This explains why current general equilibrium models tend to assume that a subset of firms index prices to lagged inflation.

In this section we will argue that the focus on monetary policy shocks has led researchers to model frictions that are not truly structural, in the sense of being robust to all shocks in the economy. In fact, price and inflation inertia are not universal features of the data. This can be plainly shown by analysing the response of prices to technology shocks[5].

The identification of the technology shock in this section is analogous to Galí (1999) and Altig et al. (2003). Technology shocks are defined as the only source of the unit root in labor productivity[6]. We estimate VARs for six countries: the US, Canada, France, the United Kingdom, Italy and Germany. For each country we estimate a bivariate VAR and a multivariate VAR. The bivariate VAR is composed of the change in productivity and the inflation rate (either measured as the change in the CPI or the change in the GDP deflator). In the multivariate VAR, three more variables are added to the system: the change in total number of workers (for the US, the change in total number of hours worked), the change in real wages and the nominal interest rate. A description of the data is presented in Appendix A.

All the VARs were estimated with four lags. The sample period varied from country to country (due to data constraints): 1959Q1-2002Q4 for the US; 1961Q1-2002Q4 for Canada; 1978Q1-2002Q4 for France; 1962Q2-

2002Q4 for the United Kingdom; 1970Q1-2002Q4 for Italy; and 1970Q1-1995Q4 for Germany.

The solid lines in Figure 1 represent the impulse responses of inflation to a one standard-deviation positive technology shock in the bivariate systems. The grey areas correspond to two standard error bands around the impulse responses[7]. Figure 2 presents the impulse response of inflation to a positive technology shock in the multivariate systems. The bivariate and multivariate systems yield quite robust results. After a positive technology shock, inflation falls contemporaneously and the largest response occurs on impact[8]. After this contemporaneous jump, inflation returns monotonically to the steady state level in all countries, with the exception of Germany[9]. The robustness of these empirical patterns is confirmed by the evidence presented in Galí (1999), Altig et al. (2003) and Edge, Laubach and Williams (2003) for the US, using VARs with larger sets of variables.

The flexibility of the response of prices to technology shocks is therefore as robust a result as their stickiness in response to monetary policy shocks. This conclusion is inconsistent with the existence of an exogenously-given degree of inflation inertia in the firms' behavior.

The difficulty in reconciling the protracted response of inflation to a monetary policy shock and its immediate response to a technology shock is evident in several recent contributions that study the impact of technology shocks in general equilibrium models with price frictions, most notably Altig et al. (2003), Edge et al. (2003), Smets and Wouters (2003), or Tambalotti (2002). Even though these models embed several nominal and real frictions, none is able to simultaneously capture the heterogeneous response of inflation to both shocks. From the above contributions, the only model that captures the magnitude of the drop in inflation after a positive technology shock is Edge et al. (2003). However, this model also implies that the highest response of inflation to a monetary policy shock is in the period immediately after the shock (it is zero by construction in the period of the shock). All the other cases are quite successful in reproducing the impact of the monetary policy shock but imply a slow response of inflation after a positive technology shock, with the biggest fall in inflation occurring 2 or 3 quarters after the shock.

This contrasting ability to match the data can be traced to the respective inflation equations. In Edge et al. (2003) the estimated inflation equation is approximately

$$\pi_t = 0.979 E_t \pi_{t+1} + 0.163 \cdot mc_t$$

where mc_t represent the real marginal costs of the economy, averaged across firms. In contrast, Smets and Wouters (2003b) estimate the following dynamics for inflation

$$\pi_t = 0.688 E_t \pi_{t+1} + 0.308 \pi_{t-1} + 0.007 \cdot mc_t$$

There are two crucial differences between these equations. The first is the coefficient on real marginal costs. In a benchmark Calvo-type model this coefficient can be used to derive the fraction of firms that are able to optimally change prices in each period (and the respective mean duration of prices). While in Edge et al. (2003) we can infer that the fraction of firms optimally choosing prices in each quarter is about 33 per cent (average duration of 3 quarters)[10], Smets and Wouters (2003b) estimate that only 9.5 per cent of firms reoptimize prices in each quarter (average duration of about 10 quarters). The second difference between the equations is the presence of inflation inertia in Smets and Wouters (2003b). As mentioned above, this term is crucial to embed intrinsic inflation inertia in the model. This is useful to replicate the inflation response to a monetary policy shock, albeit at the cost of imposing this inertia in the response to all the other shocks in the model.

The different degrees of price rigidity and the presence/absence of a significant lagged inflation term explain the opposing success of each model in reproducing the response of inflation to the monetary and the technology shocks. There is a clear trade-off of exogenously imposing price rigidity in the goods market. The higher this price rigidity, the easier it is to reproduce the response of inflation to a monetary shock but the harder it becomes to capture its response to a technology shock (and vice-versa).

In sum, the VAR evidence on the response of inflation to a technology shock shows that the main underlying friction of the goods markets cannot be an exogenously-given constraint on the price-setting behavior of firms, as implied by the Calvo model. In fact, any time-dependent rule will fail to capture the distinct response of inflation to different shocks described above. This difficulty is also present in standard state-dependent models where firms face fixed costs of changing nominal prices (as in Dotsey, King and Wolman, 1999). Other alternatives to model price dynamics in the goods markets are therefore needed, and some recent modeling proposals are discussed in section 5.

3 Comovement of prices and marginal costs

The evidence in the last section showed that prices move contemporaneously in response to technology shocks. This suggests that prices may change when their underlying fundamentals also change. In this section, our aim will be to assess the extent to which the aggregate price data in our cross-section of countries adheres to this hypothesis. We will first recall the price determinants in the context of a simple frictionless model. Subsequently, we will assess whether, for the economy as a whole, the unconditional correlation between prices and these determinants is contemporaneously significant.

Consider a simple monopolistic competitive model, with a continuum of firms which produce differentiated goods, indexed by i. The demand for good i is given by

$$Y_{it} = \left(\frac{P_{it}}{P_t}\right)^{-\frac{\mu}{\mu-1}} Y_t,\ \ \mu > 1 \tag{1}$$

where P_{it} is the price of good i, $\mu/(\mu-1)$ is the demand elasticity of good i, P_t is the aggregate price level and Y_t is the aggregate output. Each firm has the following Cobb-Douglas production technology:

$$Y_{it} = (K_{it})^{\alpha} (N_{it})^{1-\alpha} \tag{2}$$

where K_{it} and N_{it} are the capital and labor inputs. Assuming that all markets are perfectly competitive, and given the demand function (1), profit maximization implies that the firm will set prices as a constant mark-up μ over marginal costs:

$$P_{it} = \mu \frac{1}{1-\alpha} W_{it} \left(\frac{N_{it}}{K_{it}}\right)^{\alpha} \tag{3}$$

where W_{it} is the nominal wage rate.

With a Cobb-Douglas technology, marginal costs are proportional to nominal unit labor costs. Taking into account that all firms behave symmetrically in equilibrium, we can rewrite (3) as follows:

$$P_t = \frac{\mu}{1-\alpha} \frac{N_t W_t}{Y_t} \tag{4}$$

Equation (4) shows that, in this simple set-up, firms set prices as a constant over nominal unit labor costs. These two series should therefore comove perfectly. This is the model prediction that will be evaluated with our quarterly dataset.

Due to data constraints the sample period varied from country to country: 1947Q1-2002Q4 for the US; 1961Q1-2003Q1 for Canada; 1979Q2-2003Q1 for France; 1959Q3-2002Q4 for the United Kingdom; 1980Q1-2003Q1 for Italy; and 1961Q4-1990Q4 for Germany. It should be highlighted that an ideal data set for these calculations should meet two criteria: first, the wage bill should include all wages and salaries (including bonuses), adding the employer's contributions to social security and subtracting employment subsidies; second, the measure of prices should correspond to the prices actually received by firms, which implies subtracting indirect taxes from gross value added. Whenever possible, the database controls for these characteristics[11].

In levels, prices and unit labor costs move very closely in all countries under study (see Figure 3). However, since these are non-stationary variables, simply looking at the levels of the variables is not a useful exercise. To uncover the business cycle features of these variables, we detrended them with an Hodrick-Prescott filter, with $\lambda = 1600$. By construction, this procedure also stationarises the variables, which is particularly useful since we are interested in computing correlation coefficients between them.

The results of this exercise are presented in Figures 4 and 5. It is clear that the contemporaneous correlation between the cyclical components of prices and unit labor costs is quite high. Despite the shortcomings of some of the data, this close comovement is found in all countries (ranging from 0.78 in the US to 0.97 in France). This contemporaneous correlation is of an order of magnitude similar to the cyclical correlation usually computed between consumption and output or between total hours and output. Such high correlations suggest that prices do move significantly with their underlying fundamentals.

Another feature that is visible from Figure 4 is that the volatility of unit labor costs is higher than the volatility in prices in most countries. Therefore, while most of the cyclical movement in prices can be traced to movements in firms' unit labor costs[12], the data also uncovers some significant variability in the firms' mark-ups (which equation (4) assumed constant). Several contributions have suggested that this variability may be due to the presence of significant price rigidities in the data (see Sbordone, 2002). However, this pattern may also be related to the fact that we are assuming that marginal costs can be measured by nominal unit labor costs. In fact, even within the context of a flexible price model, several factors may justify why these measures do not comove fully. Notable among these are the existence of overhead labor, the presence of labor and capital adjustment costs, the variation in capital and labor utilization and their relative prices, the impact of changes in intermediate costs or simply the absence of a Cobb-Douglas production function (for a discussion of these issues, see the seminal contributions of Bils, 1987, and Rotemberg and Woodford, 1999).

If prices respond fairly flexibly to unit labor costs, how can we explain the persistence of prices that we observe in the data? Table 1 gives a clear answer to this question: the persistence of the cyclical component of prices is closely related to the persistence of unit labor costs. For all countries, we conclude that the persistence of the cyclical component of prices - as measured by the respective autocorrelation coefficient - is not statistically different from the persistence in the cyclical component of unit labor costs. The explanation of price persistence can therefore be moved one step backwards, to the persistence of unit labor costs.

Given this persistence, one could also conjecture that the high contemporaneous correlation between prices and unit labor costs could reflect the response of prices to *past* unit labor costs. This conjecture is not supported by the data. In fact, from Figure 5, it is clear that the highest correlation between prices and unit labor costs arises contemporaneously in all but one country of our sample[13].

This strong relation between prices and nominal unit labor costs has a counterpart in the new-Keynesian Phillips curve, where inflation is related to real unit labor costs. Some authors have argued that the significant correlation between inflation and real unit labor costs observed in the US - usually around 0.4 for the contemporaneous correlation - is evidence in favor of the Calvo Phillips curve (Galí and Gertler, 1999, and Sbordone, 2002). However, in the sample period used in these calculations - broadly the last four decades - it is debatable whether these variables are stationary or not (in the euro area countries, they are clearly non-stationary). It is therefore important to assess whether the relation between inflation and real unit labor costs is robust to the filtering of the series. In our panel of 6 countries, we find evidence against that robustness. In fact, when we detrend both inflation and real unit labor costs with an HP-filter with $\lambda = 1600$, the positive and significant correlation between inflation and real unit labor costs tends to vanish in all cases, and turns negative in three cases[14].

In conclusion, the evidence presented in this and the previous sections suggests that the assumption of flexible prices may be more appropriate than the assumption of sticky prices if the goal is a structural description of inflation dynamics. In fact, in a model with a significant degree of price stickiness, the explanation of price movements is mostly rooted on the exogenously imposed restrictions on the price-setting behavior by firms. In the Calvo model, for example, the path of inflation is mostly related to the share of sticky firms and to the share of backward-looking price setters. In contrast, a model where most prices are flexible implies that the price dynamics is broadly anchored on the determinants of marginal costs, and thus on the shocks to those determinants (for example to the demand for goods, to the labor supply or to total factor productivity). The latter model seems more robust to the various facets of the data uncovered above.

4 Re-reading some microeconomic evidence on price-setting behavior

Considering the current importance of the sticky price assumption in general equilibrium models, it is surprising that the empirical microeconomic evidence on this issue is so scarce. The available microeconomic evidence may be split in three categories: first, studies that track price changes to changes in market conditions; second, survey evidence on firm behavior; third, studies that analyze the behavior of individual CPI items through time.

There are very few microeconomic contributions that simultaneously study the behavior of prices and their underlying fundamentals. Notable exceptions are Aaronson and MacDonald (2000) and Dutta, Bergen and Levy (2002). The first authors use the CPI Food Away from Home index for 1978-97 and conclude that restaurant prices rise by statistically significant amounts in periods around minimum wage increases (arising from minimum-wage legislation). If the minimum wage increases in month t, about 60% of the price response occurs in months t and $t + 1$, this despite the fact that the minimum wage legislation is usually enacted many months in advance.

These results confirm similar findings by Aaronson (2001). Dutta, Bergen and Levy (2002) track the behavior of twelve orange juice related goods, using data on the producer, wholesale and retail trade levels. They find that retail transaction prices exhibit flexibility in response to changes in costs. In fact, the transmission of wholesale to retail and of spot to retail prices is, in almost all cases, completed within a quarter. Another contribution to this literature may be found in Roberts, Stockton and Struckmeyer (1994). These authors estimate monthly aggregate and industry price equations for the manufacturing sector in the US for the period 1958-1983. They conclude that the price adjustment to a shock is quite rapid, with more than 95 per cent of the price adjustment completed after 1 quarter. These results are obtained either with industry or with aggregate data.

A second set of studies asks firms about their price-setting behavior. Notable among these are Blinder, Canetti, Lebow and Rudd (1998) for the US and Hall, Walsh and Yates (2000) for the UK. Blinder et al. (1998) surveyed 200 firms and found that the median firm adjusts prices once a year. This number has become a rule-of-thumb benchmark in sticky price models (see also Taylor, 1999). Hall, Walsh and Yates (2000) conducted a survey on 654 UK companies and found that the median firm changed prices every two quarters (although the median firm reviewed prices every month).

However, as already mentioned before, the frequency of price changes reveals little about the stickiness of prices. In fact, it may simply reflect a case where market and cost conditions did not change significantly. Interestingly, Blinder et al. (1998) ask directly for evidence on this issue. When asked how long it would take for firms to change prices after significant cost or demand shocks, the average response in all cases was around 3 months. This is evidence pointing to at most one quarter price rigidity. This corresponds to a high degree of price flexibility compared with most sticky price calibrations.

A third set of studies focuses on the behavior of CPI items. Lach and Tsiddon (1992) analyse monthly data used by Israel's Central Bureau of Statistics to compute the CPI. Their data concern prices of 26 foodstuff products in Israel during the high inflation period of 1978-84. In the sample period, the average duration of a price quotation is 1.9 months in 1978-79 (with a monthly inflation of 4.9% in Israel) and 1.6 months in 1981-82 (with a monthly inflation of 6.6%)[15]. Eden (2001) updates Lach and Tsiddon (1992) with data for 1991-92 (when average annual inflation in Israel was 8.7%). The data contains 115394 monthly observations of prices collected from 458 stores which sold 390 different products. The average time between two consecutive nominal price changes was 2.7 months in this period. It can again be concluded that on a quarterly basis, the flexible benchmark is a good proxy for the average price behavior, not only in high-inflation cases, but also when rates of inflation are below 10%.

Burnstein, Eichenbaum and Rebelo (2003) study four large devaluation episodes, in Mexico, Korea, Brazil and Argentina. They conclude that there is a fast adjustment in the prices of tradable goods and a slow adjustment in the price of non-tradable goods. In the case of Argentina these authors show that, between March and December 2002 (when a large devaluation of the peso was taking place), the median *weekly* frequency of price changes was 29.5 per cent for tradable retail goods and 0 per cent for services[16]. This asymmetry suggests that the respective price fundamentals changed differently with the devaluation. Burnstein et al. (2003) argue that a key explanation for this lies in the absence of wage pressures in the non-tradable goods sector after the devaluation.

Dias, Dias and Neves (2003) studied a database comprising 3000000 observations on monthly price changes of about 600 non-housing prices included in the Portuguese CPI between 1992 and 1997. In this period, average annual inflation in Portugal declined significantly, from 9.5 per cent to 2.3 per cent (with an average of 5.2 per cent in the 7-year period). They report that prices changed on average once every 4.5 months.

Finally, Bils and Klenow (2002) have recently challenged the consensual view on price changes in the US[17]. Analyzing prices on 70000 to 80000 non-housing goods and services between 1995-1997, they report that the median duration of prices is 4.3 months (median monthly frequency of price change equal to 21% and median quarterly frequency of price change equal to 51%[18]). Other data concerning the most recent period suggests that the median duration is below 4 months (which corresponds to a median quarterly frequency of price change over 54%). Moreover, they also present results for the average monthly frequency of price changes in 1997. The reported average duration is only 3.3 months (average quarterly frequency of price change equal to 60%).

In conclusion, both in high-inflation and low-inflation cases, the majority of consumer prices changes every quarter. When averaged across the whole economy, there is no evidence of an overall degree of price rigidity of over one quarter. The average pricing behavior would actually tend to favor the case of quarterly price flexibility. The microeconomic evidence on individual price movement is thus consistent with the above microeconomic analysis of firm behavior.

Since the focus of this section was aimed at the *average* quarterly pricing behavior, we neglected the evidence that points to a significant degree of heterogeneity in price-setting behavior by firms. While some prices adjust rapidly (for example commodity prices and foodstuffs) others stay constant for long periods, sometimes years. This immediately suggests that it may be useful to model the economy with (at least) two sectors, one composed of rather flexible goods and the other composed of rather sticky goods. This avenue is pursued in Bils and Klenow (2002).

5 Reconciling general equilibrium models with the empirical data

In the previous sections, we showed that prices behave fairly flexibly in response to their underlying fundamentals. In particular, it was concluded that prices are not sticky *per se* and behave sluggishly only in response to a particular set of shocks. This observation implies that price stickiness cannot be modelled as an exogenous feature of the environment, unrelated to other features of the economy. Time dependent pricing models, such as Calvo (1983), are not particularly helful in this context. In order to reproduce the heterogeneous response to different shocks, price (and inflation) persistence must arise as an endogenous feature of the environment. This is an important constraint on the frictions that are suitable for understanding the functioning of price setting behavior by firms.

In this context, and given that a standard sticky price model has difficulties in accounting for the response of inflation after a technology shock, a straightforward question is whether a flexible price model does not also have difficulties in accounting for the protracted response of inflation after a monetary policy shock. Several papers have recently contributed to this debate and allow an unambiguous 'no' answer to that question.

In the remaining of this section we briefly review some of these models. They share the common feature that no exogenous restriction on the frequency of price changes by firms is introduced. The heterogeneity of the proposed frictions suggests that many paths hold the promise of reconciling a flexible-price framework with the data. To endogenously generate price persistence these models focus either on the behavior of households, on the behavior of firms, or on the monetary policy authority.

A first set of models shows that the behavior of households may explain price rigidity after a monetary shock. On the one hand, Alvarez, Atkeson and Edmond (2003) and Edmond (2003) show that introducing heterogeneity in the households' velocity of circulation of money generates a slow response of prices to a monetary shock, since demand becomes sticky. In their model households are assumed to have the opportunity to transfer funds to their bank accounts only once every N periods. In this context, a monetary injection implies that agents trading in the financial market at that point in time will hold a disproportionate amount of money. Since these agents have a low propensity to consume and hold a disproportionate amount of money, aggregate velocity decreases and prices respond sluggishly to the monetary shock. On a very different line of investigation, Rotemberg (2002) shows that in a model where customers react negatively when they believe that price changes are unfair, firms will avoid changing prices too often, making prices sticky.

A second set of models roots price stickiness directly on the behavior by firms. Christiano et al. (2001) argue that frictions in the labor market coupled with habits in preferences for consumption, variable capital utilization and a cost-channel are sufficient to generate the VAR response of inflation to a monetary policy shock. Golosov and Lucas (2003) suggest that firms incur in menu costs when changing prices and are subject to economy-wide (inflation) and idiosyncratic (productivity) shocks. Their model is able to replicate the monthly fraction of firms changing prices both in low and high inflation economies. Woodford (2002) presents a noisy-information model with monopolistic competition and in which pricing decisions are dependent upon prices set by other firms. If there is limited processing capacity of information by firms, and if strategic complementarities are strong, prices adjust sluggishly after a monetary policy shock and the real effects of this shock are large. Finally, Johri (2003) introduces a learning by doing mechanism in the production process, assuming that current production is an input into future productivity. The interaction between pricing policies and future productivity induces firms to optimally choose stickier prices than in the absence of learning by doing.

The third set of models focuses on the behavior of the monetary authority. Prominent among these is Dittmar, Gavin and Kydland (2003), who argue that the monetary policy rule can turn output persistence in inflation persistence, creating positive cross-correlations between inflation and output. They argue that a frictionless model where the monetary authority follows a Taylor rule can account for the cross-correlation between inflation and deviations of output from trend observed in the US.

It is clear that there is no lack in supply of models that endogenously generate price persistence after monetary policy shocks and that can also replicate flexible price responses after technology shocks. The frictions underlying these proposals are quite disparate, though not always incompatible. Given their novelty it is still too early for there to be a clear convergence towards a dominant paradigm.

6 Conclusion

In this paper we presented a broad set of facts suggesting that a flexible price benchmark may be more appropriate than a sticky price benchmark in modeling the goods markets. First, it was shown that in a sample of 6 countries, prices respond flexibly to technology shocks. This implies that sticky prices are not the structural friction - by definition invariant to shocks or policy changes - that characterizes the goods markets. Second, it was shown that the unconditional correlation between the cyclical components of prices and unit labor costs is high (and highest) contemporaneously. Finally, some microeconomic evidence was briefly surveyed, which shows that prices change significantly when their fundamentals support that move.

This evidence points to a higher degree of price flexibility - on a quarterly basis - than is usually assumed in the literature. This implies that in general equilibrium models price rigidities should mostly arise as an endogenous feature of the equilibrium rather than being exogenously imposed to the model.

From a general equilibrium modeling perspective, assuming that a nominal friction lies in the goods market when it is rooted in some other feature of the economy may temporarily survive the scrutiny of the data but does not survive the Lucas critique. Moreover, it changes the ability of the model to answer useful economic questions in an important way. For example, Christiano and Fitzgerald (2003) convincingly show that inflation in the US was much more volatile and less persistent in the first half of the century relative to the second half, despite being lower on average. In interpreting this evidence, a sticky price model would suggest that in the first half of the century firms either faced lower menu costs or lower informational frictions in identifying the shocks hitting the economy. A sticky wage model, in contrast, would suggest that contracts had a lower duration in the first half of the century. It is clear that the choice of underlying frictions radically changes the lessons to be learned from these models.

Many avenues are open to reconcile flexible price models with the sluggishness in inflation that is observed, for example, after a monetary policy shock. Among these are models that focus on wage contracts, on different information processing capabilities by agents, on fear of the response of customers or competitors to changes in the firm's prices and on the existence of real menu costs. This literature is rapidly expanding and the crystallization into a dominant paradigm is yet to be visible.

The quest for a model that describes the behavior of economic agents under a broad set of circumstances is not only important for positive analysis but also to identify the optimal goals of policy from a welfare point of view. For example, the current consensus around price stability as the optimal goal of monetary policy is closely related to the sticky price assumption embedded in the models. In contrast, a model with sticky wages but flexible prices would imply that the optimal policy would be the stabilization of nominal wage growth (as in Erceg, Henderson and Levin, 2000). Seeking to stabilize wage inflation implies in most cases a very different policy relative to the stabilization of price inflation. The choice of modeling assumptions has therefore a profound impact on the policy recommendations stemming from the models. The importance of these assumptions calls for further study and discussion of their empirical and theoretical foundations.

Notes

[1]The literature building on the benchmark sticky price model has grown exponentially in the last few years. In particular, recent models take into

account the presence of wage frictions, habit preferences in consumption, variable capital utilization, costly adjustment of investment or information lags in the households' decisions (see Woodford, 2003, for an account of many of these models).

[2]The importance of the assumption can be illustrated with Davis and Hamilton (2003). In this paper, the authors explain why wholesale gasoline prices are *sticky*, since they only change every two or three days while the underlying price of gasoline changes almost every day.

[3]See, however, Uhlig (2001) who questions some of these facts, in particular the output response.

[4]See, however, Woodford (2003) for a criticism of the assumptions in Chari et al. (2000) and for a presentation of some extensions that reconcile the standard model with the data.

[5]The choice of technology shocks should come as no surprise since the early contributions to the real business cycle theory relied exclusively on these shocks to explain the business cycle properties of the data.

[6]As emphasised by Altig et al. (2002), this identification scheme may be attributing to technology shocks the impact of other shocks which affect labor productivity in the long-run, such as changes in capital taxes. For the purposes of this paper, this distinction is not crucial, since the argument rests on there existing (some) shocks that move prices flexibly.

[7]These are Monte Carlo Bayesian confidence intervals, computed using random draws from the posterior distribution of the covariance matrix of innovations and the reduced form coefficient matrix.

[8]A full set of results from all the VARs is available upon request. Interestingly, in 5 countries the real wage jumps significantly on impact after the technology shock (in France the response in non-significant). The magnitude

of the jump suggests that most of it can be attributed to the contemporaneous fall in prices. As for the number of workers/hours they fall significantly in the US, Canada, UK and Italy and record a non-significant change in France and Germany.

[9]The evidence for Germany is less clear-cut in this respect, since the response of inflation is non-significant most of the time.

[10]This calculation is for illustration purposes only. In fact, Edge et al. (2003) do not derive the inflation equation from a Calvo-type model.

[11]The first criterion is met by all countries in the database. The second criterion is met by the data for all countries except Canada and Germany. Note also that since the producer prices in the French data reflect the taxes on production, we included all intermediate consumptions (which comprise those taxes) in the unit labor cost series for France.

[12]Simple regressions of prices on unit labor costs show that, in all countries, more than two thirds of the variation in prices can be explained by movements in unit labor costs. These regressions are available from the author upon request.

[13]Canada is the exception. However, in this case the highest correlation is between current prices and *future* unit labor costs.

[14]These cases are France, Italy and Canada. The full set of correlations is available from the author upon request.

[15]In their data set, prices are recorded monthly. Therefore it is likely that the above numbers are biased upwards.

[16]Their survey comprises 53 goods and 10 services.

[17]Besides Blinder et al. (1998) other studies also found a significant degree of price rigidity in the US (for example, Cecchetti, 1986, who studied magazine prices and Kashyap, 1995, who studied retail catalog prices). However,

these studies focused on very specific goods, which are not representative of the overall consumer basket of goods and services.

[18]This is the instantaneous probability of price change. It assumes that prices can change at any moment (and not just the quarterly interval). The fraction of firms that changes prices in this case is equal to $1 - e^{\left(-\frac{1}{\theta}\right)}$, where θ is the duration of prices. If it was assumed that prices could only change once every quarter - an implicit timing assumption in the theoretical models - the fraction of firms changing prices each quarter would equal $\frac{1}{\theta}$. As an illustration of the differences involved, if the mean time between price changes is three months, the first formula implies that 63% of firms adjust prices each quarter, while the second formula implies that 100% of firms do so.

A Description of the data

Data for the US

The raw series used for the US were the following: unit labor costs of the non-farm business sector (source: BLS); non-farm business sector gdp deflator (source: BEA); Gross Domestic Product, in chained (1996) dollars (source: BEA); Federal Funds rate (source: IMF); nominal wages per hour (source: BLS); and, total hours in the non-farm business sector (source: BLS).

Data for the UK

The raw series used for the UK were the following: unit labor costs for the whole economy (source: Office of National Statistics); implied deflator of Gross Value Added at basic prices (source: Office of National Statistics); Gross Domestic Product at constant 1995 prices (source: Office of National Statistics); overnight interbank rate, retropolated (before 1972Q1) with the

Treasury Bill rate (Source: IMF); nominal wages per worker (source: Office of National Statistics); and, UK workforce jobs (source: Office of National Statistics) retropolated (before 1978Q2) with series from the UK Department of Labor.

Data for Canada

The raw series used for Canada were the following: unit labor costs, calculated from data on GDP at basic prices and compensation of employees (source: OECD Quarterly National Accounts Statistics); GDP deflator (source: IMF); real output at basic prices (source: OECD Quarterly National Accounts); official discount rate (source: IMF); total compensation (source: OECD, Main Economic Indicators); and, civilian employment (source: OECD).

Data for Italy

The raw series used for Italy were the folowing: unit labor costs, calculated from data on total income from employment and GDP at basic prices (source: Conistat); GDP at basic prices deflator (source: Conistat); value added at basic prices (source: Conistat); three-month money market interest rate (source: IMF); wages per person (source: IMF); and, civilian employment (source: OECD).

Data for France

The raw series used for France were the following: non-financial enterprises total unit cost (source: INSEE); non-financial enterprises producer prices (source: INSEE); Gross Domestic Product (source: INSEE); call money rate (source: IMF); nominal wages per hour (source: BLS); and, employees in market industry and services (source: OECD).

Data for Germany

The raw series used for Germany were the following: unit labor cost of mining and manufacturing (source: OECD); GDP deflator (source: IMF); GDP volume at 1995 prices (source: IMF); call money rate (Source: IMF); nominal hourly earnings in manufacturing (source: OECD); and, wage and salary earners (source: Bundesbank).

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Country	**Prices**	**ULC**
US	0.87 (0.06)	0.83 (0.04)
UK	0.86 (0.05)	0.90 (0.04)
Canada	0.92 (0.03)	0.91 (0.04)
Italy	0.79 (0.06)	0.84 (0.04)
France	0.94 (0.04)	0.94 (0.04)
Germany	0.73 (0.07)	0.69 (0.09)

Table 1: Persistence of the cyclical component of prices and unit labor costs, as measured by the coefficient of an AR(1) applied to the respective series (with heteroscedasticity and autocorrelation consistent standard errors in parenthesis, following Andrews, 1991)

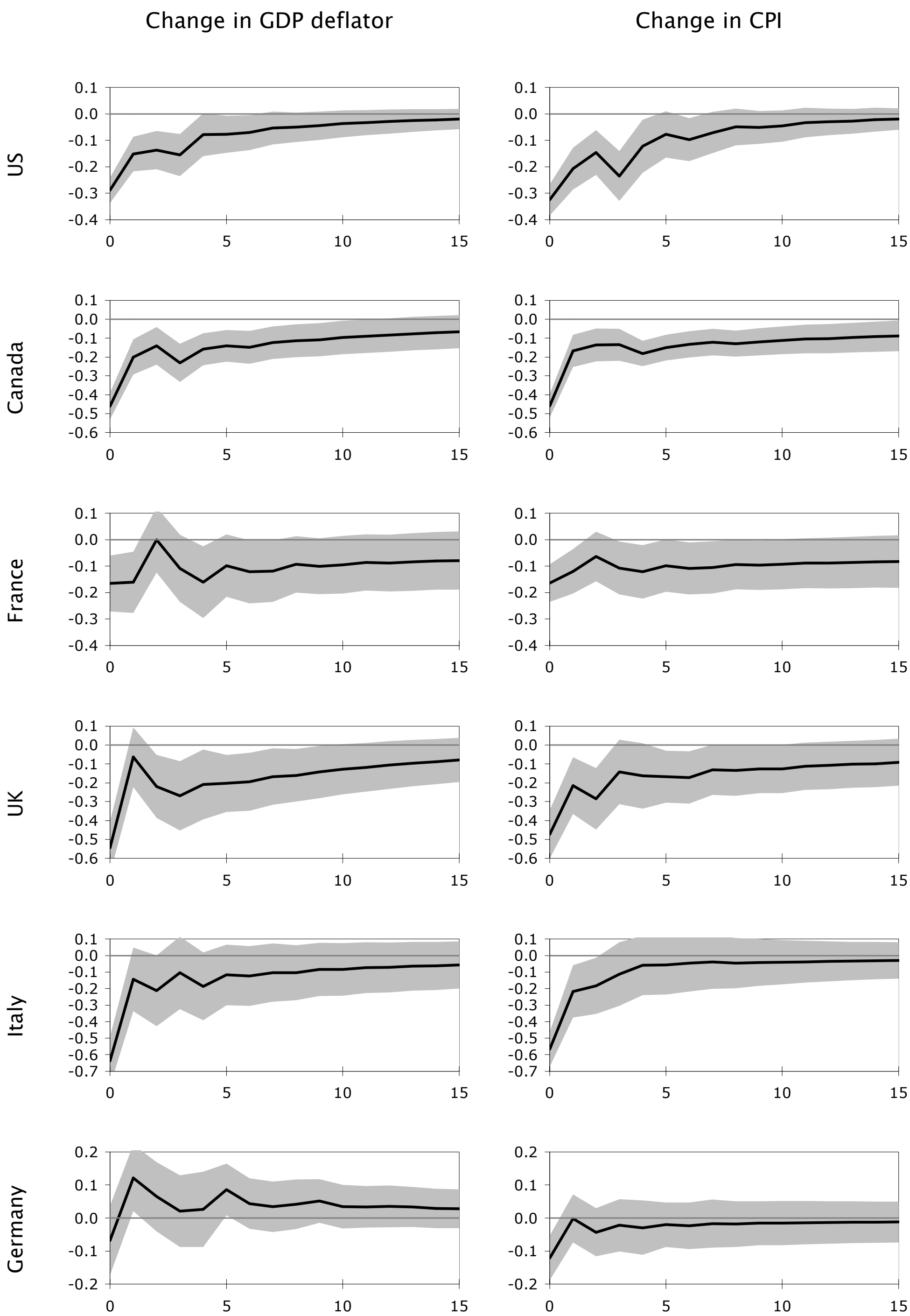

Figure 1: Response of inflation (measured by either the per cent change in the GDP deflator or the per cent change in the CPI) to a positive technology shock in bivariate VARs.

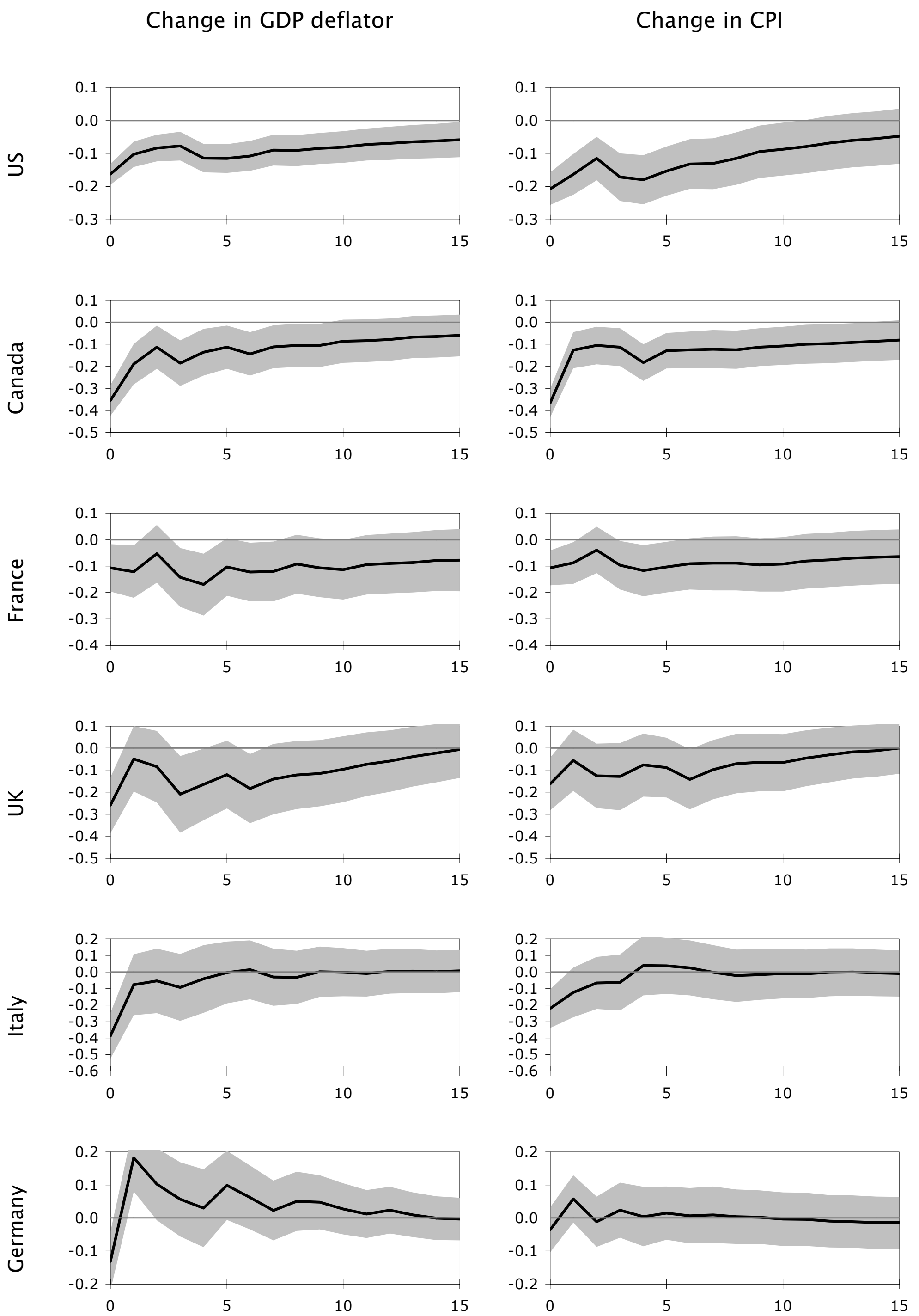

Figure 2: Response of inflation (measured by either the per cent change in the GDP deflator or the per cent change in the CPI) to a positive technology shock in 5-variable VARs.

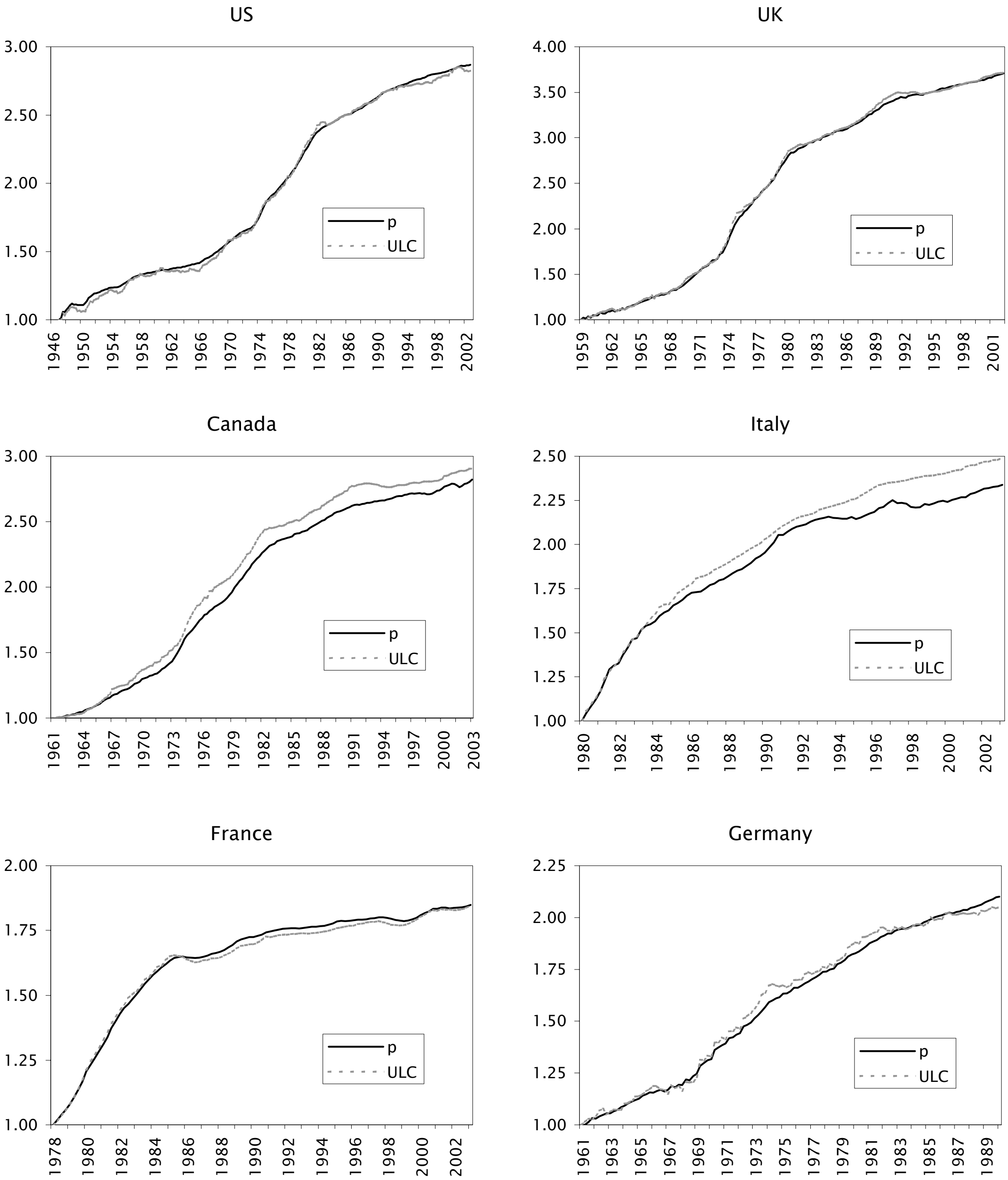

Figure 3: Prices and unit labor costs in levels (logarithmic scale).

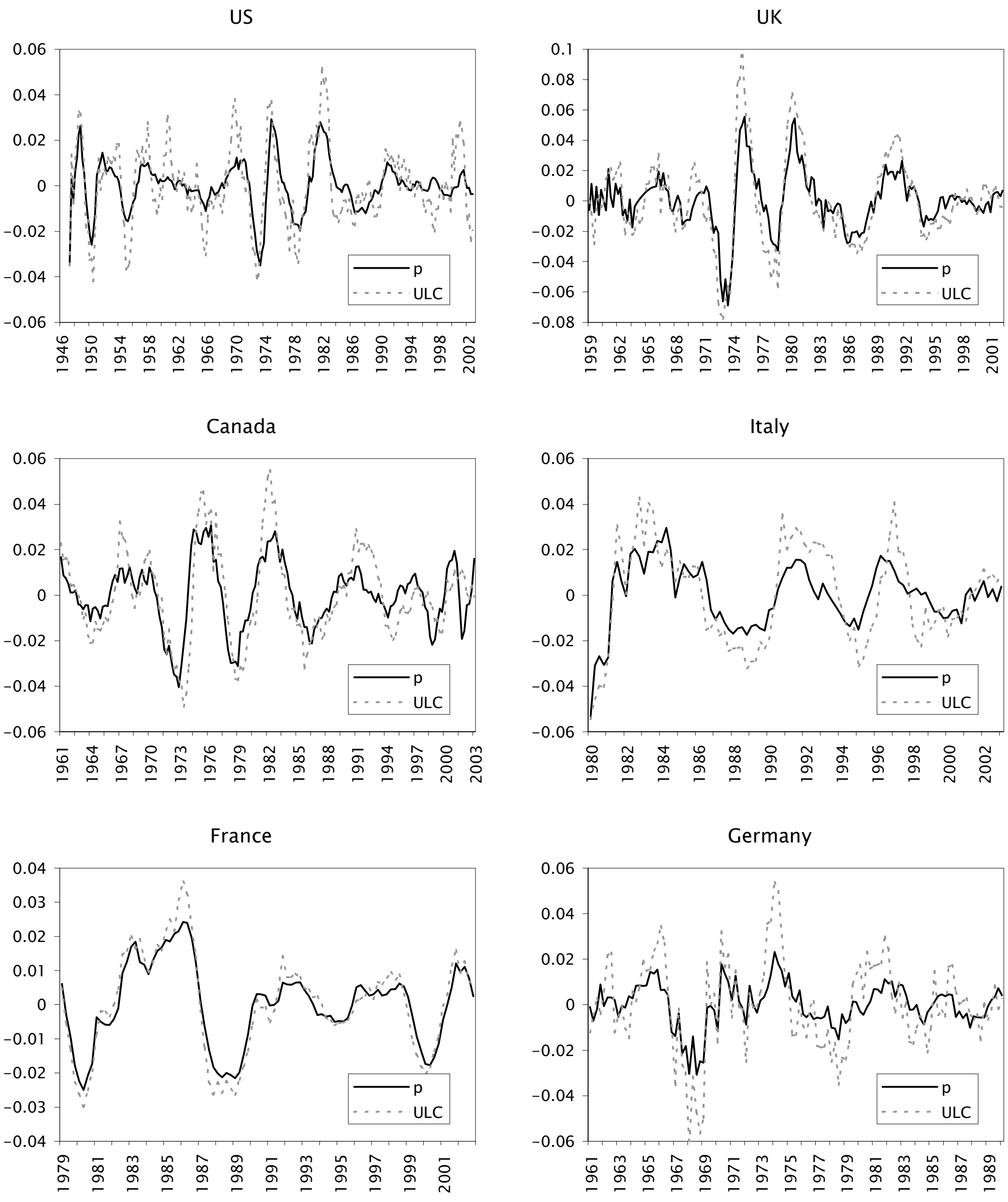

Figure 4: Cyclical component of prices and unit labor costs. Variables detrended with an HP filter with $\lambda = 1600$.

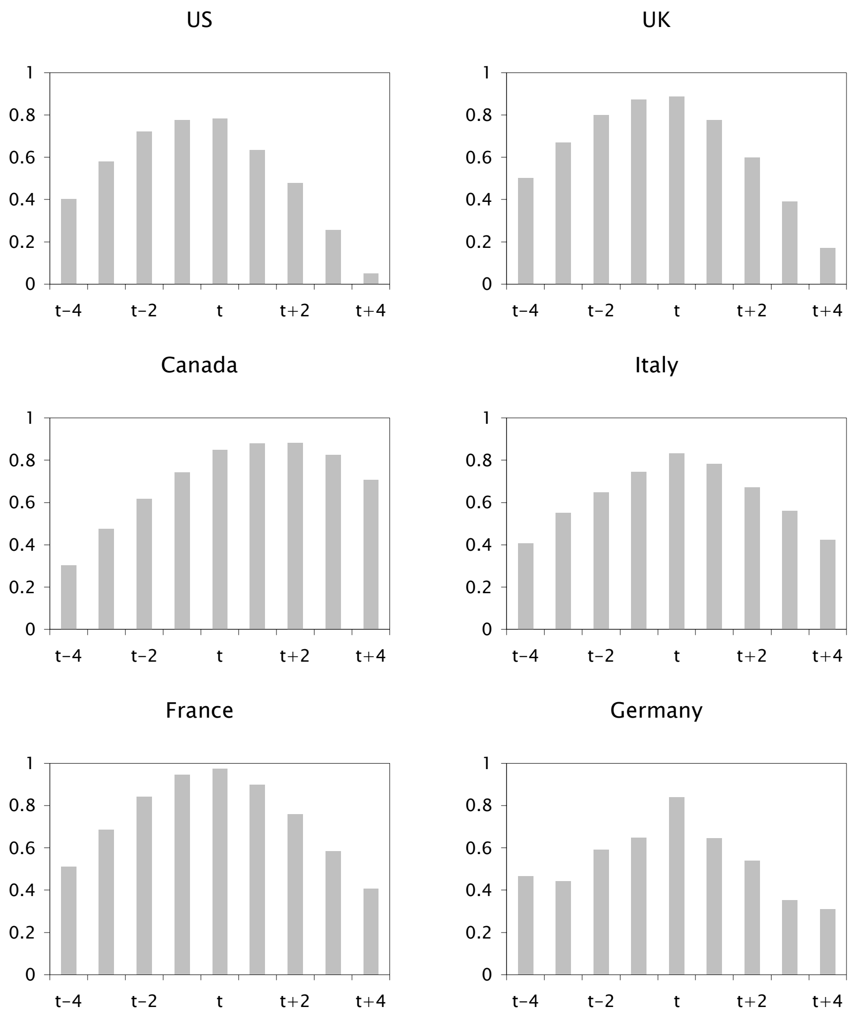

Figure 5: Cross-Correlation of cyclical component of prices (time t) with cyclical component of unit labor costs (time $t + j$).

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