Comments on "Implications of Microeconomic Price Data for Macroeconomic Models" by Bartosz Maćkowiak and Frank Smets

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When I was about five, my parents first brought me to Cape Cod. Reading "On the Implications of Micro Price Data for Macroeconomic Models" by Bartosz Maćkowiak and Frank Smets is like a trip to an old-fashioned candy store on such a childhood vacation. At first glance, it is a wonderful experience simply because there are so many excellent items on the shelves. Later on, one realizes just how judiciously selective the proprietors have been: they have chosen from a large universe of potential items, presenting the best and most interesting ones to the customer, and thus providing an opportunity for a real treat. But one still must make judicious choices oneself.

In this paper, Maćkowiak and Smets have worked hard to bring us the best candy, in this case the most salient features of modern research on pricing, with a stress on the implications of micro data for macroeconomic models. It is absolutely wonderful that Maćkowiak and Smets have had to work so hard. In the last 10 years, there has been an explosion of research on pricing: the work of Bils and Klenow (2004) has stimulated a new industry producing studies of price dynamics, based principally on new access to survey data collected for the consumer and producer price indexes in many countries around the world. The Inflation Persistence Network supported by the central banks of the Euro System has produced a wealth of studies for European countries. Recent investigations extend the coverage to a wide range of other countries, including countries with higher average rates of inflation. All in all, there are new opportunities and new challenges associated with this new, more detailed information on price dynamics.

In my discussion, like Maćkowiak and Smets, I am going to selectively draw from the available studies of micro price data and highlight what I see as several key implications. In particular, I am going to argue that the micro data indicates that we need to organize our thinking around a dynamic pricing model that is very far from the Calvo (1982) model. This is the model that we presently teach to first year Ph.D students and its near relatives are used in many modern quantitative dynamic stochastic general equilibrium (DSGE) models. The Calvo model, like other time-dependent pricing models, abstracts from a firm's choice of the timing of the price adjustment and focuses on the magnitude of a firm's price adjustment. Calvo's model is attractive theoretically and empirically because it leads to a simple forward-looking theory of inflation and potentially is compatible with large non-neutralities arising from sticky prices. It was precisely those aspects of the Calvo model that led me to use it in the initial quantitative DSGE studies that I undertook in the mid-1990s. But those early studies used a degree of price stickiness that is simply implausible given the micro price data that we now have. Some researchers have sought to modify the Calvo model along "dynamic indexation" lines to generate a backward-looking component of inflation and such modifications are now a key part of many quantitative DSGE models. I argue that these modifications are so grossly at variance with the microeconomic data that they should be scrapped as devices to improve the empirical performance of macroeconomic models.

Proceeding further, I think it is useful to ask: suppose that we are forced to choose between using a model that explains only the magnitude of price adjustment (as in the Calvo model) or only the timing of price adjustment? Drawing on recent empirical work of Klenow and Kryvtsov (2008) and Nakamura and Steinsson (2008a,b) on U.S. CPI data, I conclude that we want the "endogenous timing model." That is, to understand inflation, we should focus on understanding the timing rather than the magnitude of price adjustment.

1. DSGE Models with Sticky Prices

It was not always the case that there was a wealth of microeconomic pricing data. In particular, it was not the case in the mid-1990s, when economists began building a new class of small-scale DSGE models designed to allow explicit microeconomic foundations. These models included optimizing price formation by forward-looking firms, so as to undertake analysis of monetary policy consistent with the Lucas critique.

This 1990s model-building activity focused on prices, rather than wages, for several reasons. First, beginning with controversies in the 1930s, macroeconomists had become convinced that there was no firm difference between cyclical price and wage movements, so that in turn there was no strong cyclical pattern of real wages. Second, many economists found convincing the views of Barro (1977) and Hall (1980) that nominal wage bargains between firms and workers need not be allocative. For this pair of reasons, New Keynesian economists like Mankiw (1990) recommended that price stickiness be the centerpiece of new research activity, paired with imperfect competition in product markets. However, incorporating price stickiness exacts a cost in dynamic modeling: a distribution of prices is the relevant state of the economy.

1.1 The Nature of Price Dynamics

In the 1990s, as Maćkowiak and Smets stress, there was a relatively small amount of data on micro price dynamics, largely limited to studies of newspapers and catalogs. But most macroeconomists had a sense that there was important price stickiness, based on casual observation. Continuing the discussion of confections from above, Figure 6.7 shows the weekly price of a particular cookie at Dominick's Fine Foods during the 1989–1997 period. The figure highlights the pattern of price dynamics which makes macroeconomists interested in price stickiness as a potential source of monetary non-neutrality. The time scale is weekly, so that there are several periods of 6 months or more during which there are no changes in the "regular" price. In fact, the price of a package of cookies is $1.99 for most weeks during a two-year interval in the midst of the sample. The second impression is that these "constant price spells" are not of equal duration: sometimes the periods of price fixity are lengthy and sometimes these are short. The third impression is that the intervals of stickiness are occasionally interrupted by declines in the product price: there are "sales" of varying sizes and there is some tendency for the post-sale price to return to its prior level.

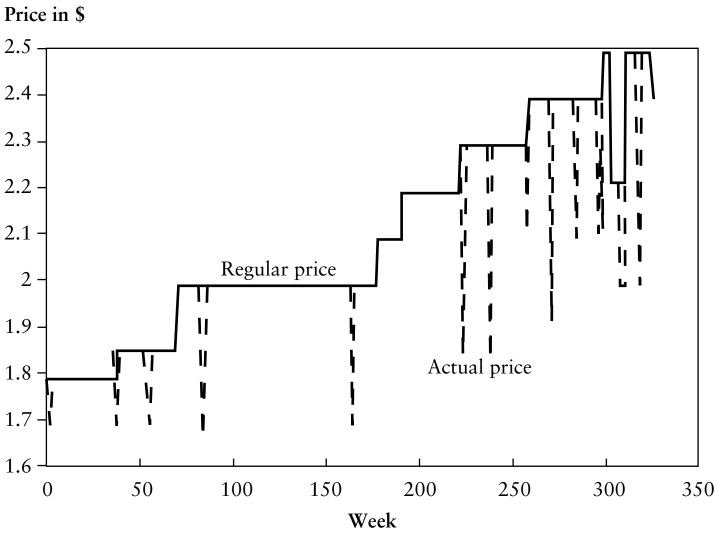

Figure 6.7
Cookie Price Dynamics: Price of a 5.5 Ounce Package of Pepperidge Farm Geneva Cookies at Dominick's Fine Foods, 393 Weeks Starting 09/28/89
Source: Dashed line is price obtained from the Dominick's data base at the University of Chicago Booth Graduate School of Business. Solid line is an estimate of the regular price, using a sales removal filter developed by Johnston (2007).

Figure 6.7 includes the underlying actual price data, including sales, as shown by the dashed line. Klenow and Kryvstov (2008), Nakamura and Steinsson (2008a), and other studies remove price changes that are temporary, such as sales. Such a filtering of price data yields an estimate of the product's "regular price," shown as the solid line in Figure 6.7. There are 10 regular price changes in the figure, so that the product price is constant for about 35 weeks on average and there is a regular price change in about 3 percent of the weeks in the sample. There are 13 sales intervals, so that including these episodes, which involve both a decrease and an increase in the price, leads to a greater estimate of the frequency of price changes.

Given the price dynamics such as those described in Figure 6.7, as argued by Rotemberg (1987), a natural first approach is that of Calvo (1982) since it can capture periods of price fixity of apparently random length, thus producing consistency with the first two facts. The crucial characteristic of the Calvo model is that there is an exogenous constant probability of price adjustment, unrelated to macroeconomic factors or the length of time since the last adjustment. At the level of the firm, the focus is thus on the intensive margin of price adjustment: how should the size of the "steps" in Figure 6.7 be determined?

However, in terms of developing quantitative DSGE models, there are other reasons that the Calvo model is attractive, in that it allows for a simple aggregation of a distribution of prices with only a single free parameter in the aggregator. It is that aspect of the model that led it to be used in early quantitative DSGE models and mainly accounts for its continued popularity in dynamic macroeconomic analysis.

1.2 Early DSGE Models with Sticky Prices

For a combination of tractability and empirical relevance, an initial set of DSGE models was built around a real business cycle core, modified by the introduction of monopolistic competition, sticky prices, and with various approaches to money demand. Yun (1996) developed a coherent aggregation theory for a version of the Calvo setup, constructing a framework within which Solow growth accounting and, in particular, the extraction of productivity shocks was legitimate under sticky prices. Empirically, Yun used his framework to explore the dynamic interaction of inflation, output, productivity, and monetary variables. King and Wolman (1996) focused on the policy implications of a broadly similar DSGE model, stressing that such a "St. Louis model of the 21st century" provided strong support for inflation targeting: a smooth price path made the model operate as if prices were not sticky, so that real activity responded to productivity shocks just as in the real business cycle model—although the level of real activity was reduced due to monopoly distortions. King and Watson (1996) studied the empirical performance of the DSGE Calvo sticky price model, contrasting its explanatory power for money, interest, prices, and the business cycle with some competitor macroeconomic models.

Models constructed along DSGE-Calvo lines are now prominent in two settings. First, these are part of the standard fare of first-year graduate macroeconomics classes at many universities. Second, descendants of these models are now routinely used for certain monetary policy analyses at central banks.

There has been substantial growth in computational capacity since the mid-1990s, so that much more elaborate time-dependent pricing models can easily be constructed. Such models share the Calvo model's focus on the magnitude of price adjustment—the size of the "jumps" in Figure 6.7—while relaxing the assumption that the probability of price change is independent of time since last adjustment. I will return to discussing aspects of these more elaborate models in section 4 below, but will concentrate on the Calvo model itself as a representative of the broader class. The Calvo model allows for neat aggregation of the influence of the past and the future, as discussed next, and transparent analytical expressions not available in for richer time-dependent pricing models.

1.2.1 Simple Dynamics of the Price Level

Suppose that the probability of price adjustment is θ; the optimal price chosen by all adjusting firms at date t is p_t^* and the price level is P_t. Then, as is familiar, the Calvo model with a constant elasticity of substitution aggregator implies that the price level evolves according to

$$(1) \quad P_t = [\theta (P_t^*)^{1-\varepsilon} + (1-\theta) P_{t-1}^{1-\varepsilon}]^{\frac{1}{1-\varepsilon}}$$

when there is a relative demand elasticity of ε. Approximation around a zero inflation stationary point leads to

$$(2) \quad \log P_t = \theta \log P_t^* + (1-\theta)\log(P_{t-1})$$

as a convenient expression for the evolution of the price level.

These expressions highlight two key features of the Calvo model that have led researchers to use it in the construction of analytical and quantitative models. One is that this model does not track a distribution of prices because the lagged price level is the relevant summary statistic for the distribution of prices Another is that there is a single parameter, θ, which governs the dynamics of the approximate price level.

1.2.2 Forward-looking Price Setting

In the Calvo model, as discussed above, the focus is on the *magnitude* of price adjustment not the *timing* of price adjustment. Further, the model produces a direct link between inflation, $\pi_t = (P_t/P_{t-1}) - 1$, and the real "reset" price chosen by adjusting firms,

$$(3) \quad \pi_t = [\theta(P_t^* / P_{t-1})^{1-\varepsilon} + (1-\theta)]^{\frac{1}{1-\varepsilon}} - 1$$

In turn, this real reset price can be modeled as an optimizing decision, with Sargent's (1978) principle that "lags imply leads" coming strongly into play. That is, given that its nominal price is sticky, a firm has a substantial incentive to forecast the inflation rate that will prevail over the duration of stickiness. In fact, the Calvo model means that firms need to forecast inflation over many future periods. That is, with probability $(1 - \theta)^j$ the firm that sets its price at t will have real price

$$\frac{P_t^*}{P_{t+j}} = \frac{P_t^*}{P_t[(1+\pi_{t+1})(1+\pi_{t+2})\ldots(1+\pi_{t+j})]}$$

in $t + j$ so that it has strong incentive to forecast inflation when setting its price.

Optimal forward-looking pricing in the Calvo model also links the optimal reset price to current and future nominal marginal cost. To a first approximation around zero inflation, the optimal reset price takes the form $\log(P_t^*) = \frac{1}{1-\beta(1-\theta)} \sum_{j=0}^{\infty} (\beta(1-\theta))^j E_t[\log(P_{t+j}) + \log(\psi_{t+j} / \psi)]$, where ψ_t is real marginal cost at date t and ψ is the corresponding steady-state value. This can conveniently be written as

$$(4) \quad \log(P_t^*) = \frac{1}{1-\beta(1-\theta)}[\log P_t + \log(\psi_t / \psi)] + \beta E_t \log(P_{t+1}^*)$$

so that there is simple recursive structure to both the backward (2) and forward (4) components of the price block under the Calvo model.

Circa 1987, at the time of Rotemberg's survey, the price structure was a very attractive modeling assumption. The Calvo model made a firm's nominal prices resemble those in Figure 6.7: constant for periods of time that were uneven, as available microeconomic data suggested. It led to convenient expressions for DSGE model development. But the microdata was pretty sketchy, limited to the prices of a relatively small number of products.

1.2.3 Dynamics of the Price Level

When quarterly models along DSGE-Calvo lines were parameterized in the mid-1990s, a standard value for θ was .1: it was assumed that only 10 percent of firms had the opportunity to adjust prices each quarter. The specification (Plevel), $\log(P_t) = \theta \log(P^*_t) + (1 - \theta) \log(P_{t-1})$, thus meant that the price level response to a step change in would be very gradual, leading to a substantial period of non-neutrality. Put another way, the average duration of a price is the reciprocal of the adjustment fraction ($1/\theta$), so that an average price was assumed to be sticky for about 10 quarters. This very gradual price level adjustment seemed promising in terms of developing a lengthy pattern of non-neutrality, so that a sticky price DSGE model might behave very differently from its underlying real business cycle core.

1.3 The Discipline of the Micro Data

The recent explosion of work on micro data contains controversies, nicely reviewed by Maćkowiak and Smets, about how to measure price changes and the consequences of alternative procedures for the extent of price stickiness (durations of price fixity). One important issue is highlighted by looking back at Figure 6.7: one must decide whether to treat temporary ("sale") price declines as price changes or not, for the purpose of studying aggregate monetary non-neutrality. Analysts differ on this topic, so that there are a range of estimates of the duration of price stickiness and the frequency of price change.

Despite these differences, the recent work on micro price data has led to a sharply different view about the degree of price stickiness relative to that which prevailed in the mid-1990s. These findings are reflected in Klenow and Kryvtsov (2008), Tables I and II, which conduct a sensitivity analysis of frequencies of price change and duration of price fixity to various measurement issues. Median frequencies of price changes range from 14 percent to 27 percent per *month*, while mean frequencies of price change range from 30 to 36 percent. Implied median durations range from 3.7 to 10.6 months, while implied mean durations range from 6.6 to 13.4 months. There is a clear message: prices are less sticky than was commonly assumed in the early DSGE literature, so that there is significant discipline imposed by the micro data on price adjustment parameters in quantitative models. Thus, in Maćkowiak and Smets, there is a substantial emphasis on finding real mechanisms that can substitute for price stickiness in delivering large and protracted responses to nominal disturbances.

2. Capturing Inflation Persistence

An additional problem with the Calvo model of price dynamics for some analysts, stressed by Fuhrer and Moore (1995), is that there is no intrinsic inflation persistence. Combining the various equations discussed above and loglinearizing around a zero inflation steady state in ways that are now familiar, one obtains

$$(5) \quad \pi_t \approx \beta E_t \pi_{t+1} + \lambda \log(\psi_t / \psi)$$

where γ is a function of β and θ. This specification is widely employed in applied work, i.e., in the extensive empirical literature exploring inflation dynamics following Galí and Gertler (1998). From this empirical perspective, the Calvo model is attractive because it is parsimonious: there is a single parameter indicating the duration of price stickiness that is a key determinant of the Phillips curve slope λ.

2.1 An Inflation Persistence Mechanism

A number of studies have sought to add backward-looking components to a forward-looking inflation specification like (5) by a variety of schemes. For example, Galí and Gertler (1999) discuss rule of thumb price-setters. More recent studies empirical studies have opted to use a scheme of "dynamic indexation," by which a firm i may update its nominal price P_{it} by

$$(6) \quad P_{it} = (1 + \pi_{t-1}) P_{i,t-1}$$

if it does not adjust to P_t^*. Such assumptions are used by many currently state-of-the-art DSGE models, such as that of Christiano, Eichenbaum, and Evans (2005) and Smets and Wouters (2003).

While there are many variants of this dynamic indexation approach, an elegant recent presentation is that of Dennis (2006). In his framework, a fraction of firms θ adjusts its price, but only a fraction ω of these adjust to P^*_t. The fraction $(1 - \omega)$ uses the dynamic indexation scheme (6). On net, this combination of assumptions yields an inflation equation of the form

$$\pi_t = b(\theta,\omega)\pi_{t-1} + f(\theta,\omega)E_t\pi_{t+1} + \gamma(\theta,\omega)\log(\psi_t / \psi)$$

which allows for a mixture of forward-looking and backward-looking components.

Estimating this model on quarterly U.S. data using Bayesian methods, Dennis (2006) finds that 60 percent of firms change prices each quarter ($\theta = 6$), but that 90 percent of these adopt the dynamic indexation rule ($\omega = .1$). That is, 54 percent of all firms have a price change that is equal to the inflation rate. These parameter estimates generate a substantial backward-looking component to the inflation, as well as a relatively low response of inflation to marginal cost. Other studies, such as that of Eichenbaum and Fisher (2007), simply impose that *all* firms adjust prices every quarter ($\theta = 1$), but estimate that only a much smaller fraction "reoptimize," setting their price to P^*.

2.2 *The Discipline of the Micro Data*

The dynamic indexation model—some variant of which is now widely employed in DSGE models designed for monetary policy analysis—is highly inconsistent with the micro data on two dimensions. First, looking at Figure 6.7, we see intervals of prices that are constant in nominal terms: cookies stay at $1.99 rather than being updated by the lagged inflation rate.

Looking more broadly, Figure 6.8 shows the distribution of price changes in the consumer price index (CPI). This figure is taken from the research of Klenow and Kryvstov (2008), where it appears as Figure II, and was kindly provided by Pete Klenow. There is a lot of relative price variability, with large positive and negative price changes being a feature of the data in both the United States and in other countries.

To think through the implications of the dynamic indexation model, let's imagine that there is a small positive inflation rate. Then, in the Calvo model, a fraction $1 - \theta$ of firms will not change price at all and a fraction $\theta(1 - \theta)^j$ will make a (log) price change of $j \log(1 + \pi) \approx j\pi$. Of

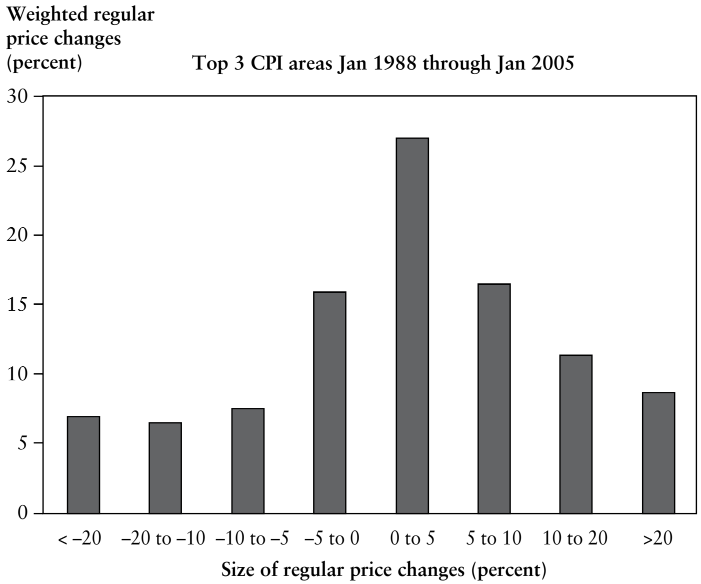

Figure 6.8
Weighted Distribution of Regular Price Changes in US CPI, 1988–2005
Source: July 2007 working paper version of Klenow and Kryvtsov (2008).

course, this completely misses on negative price changes, but it captures the fact that some firms change prices and others don't.

With dynamic indexation, a fraction $1 - \theta$ of firms do not change price, a fraction all firms $\theta(1 - \omega)$ have a price change of exactly π_{t-1}, while a fraction $\theta(1 - \theta)^j\omega$ have a price change of $j \log(\pi)$. According to the Dennis estimates described above, we should see 90 percent of all the adjustments in Figure 6.8 being exactly at the lagged inflation rate. While there are many small price changes in most data sets, which Maćkowiak and Smets appropriately stress as surprising, there is no tendency for these to cluster at last month's inflation rate. Thus, Figure 6.8 seems particularly problematic for the "dynamic indexation" because there is no "spike" in the distribution of price changes at the inflation rate, in contrast to the first-order prediction of the dynamic indexation model.[1]

Thus, there is substantial discipline present in the micro data: there is no evidence of dynamic indexation. It is my view that such discipline from the micro data is an important source of restrictions on the pricing equations in macroeconomic models, which must be imposed if we are to avoid a return to the vacuity of distributed lag econometrics latent in an earlier generation of macroeconomic policy models.

3. Micro Data and State Dependent Pricing

Many aspects of micro price data indicate that there is considerable heterogeneity in the timing of price adjustment. Starting with Bils and Klenow (2004), many researchers have documented that the average frequency of adjustment differs across product categories, across months of the year, and so on. It is hard, at least for me, to look at this considerable heterogeneity through the lens of the Calvo model or variants of it which feature heterogeneity in exogenous adjustment frequencies (the θ parameter above). But some studies reviewed by Maćkowiak and Smets do follow this strategy and these indicate that heterogeneity in adjustment frequency is itself important for macroeconomic adjustment dynamics. Fortunately, since the mid-1990s, we have the computational capability to build much larger macroeconomic models, so that it is feasible to think about heterogeneity and macroeconomics, in pricing and in other areas.

But I don't think that this sort of exogenous adjustment frequency heterogeneity is enough: we need to understand how firms choose the *timing* of their price adjustments. One particular look at the micro data suggests that it is not a sideshow, but that it is quite likely critical in terms of understanding inflation dynamics.

3.1 A Stark Choice

To put the issue sharply, let's ask a very specific question. Suppose that, despite all of the increases in computational capacity, we were forced to choose between two simple and extreme structures of pricing. One option is the familiar Calvo model which, as discussed above, assumes exogenous timing and endogenous magnitude of price adjustment: this model focuses on the intensive margin of price adjustment as key for inflation. The other option is an as-yet-undeveloped alternative model that assumes exogenous price adjustment size and endogenous timing, which I will call the simple state-dependent pricing (SDP) model to draw its connection to the literature: this alternative model would focus entirely on the extensive margin of price adjustment as key for inflation.

Neither of these setups would have a chance of explaining all of the dimensions of the micro data, of course, but we can still ask: which model would we choose for understanding inflation and why?

3.2 Investigating the Margins of Adjustment

To answer this question, it is useful to look at Figures 6.9 and 6.10, which are drawn from the unpublished research of Nakamura and Steinsson (2008b) on the U.S. consumer price index. For 1988 to 2004, they calculate these following four statistics: m^+, the average size of price increases; m^-, the average size of price decreases; f^+, the fraction of firms increasing prices; and f^- = the fraction of firms decreasing prices. Their findings, as displayed in Figures 6.9 and 6.10, are highly revealing.

The magnitude of adjustment does not move strongly with inflation. The size of price changes—particularly price increases when inflation is

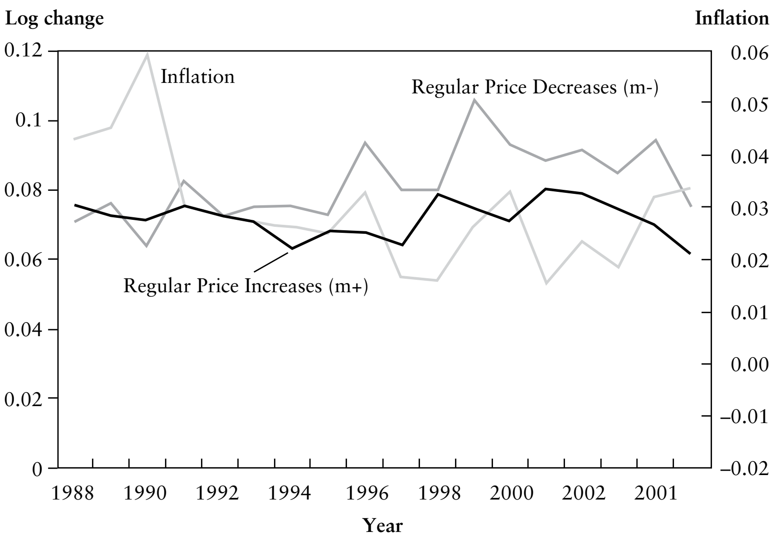

Figure 6.9
Magnitude of Regular Price Changes: The Size of Average Price Increases (m+) and Average Price Decreases (m-) in the U.S. CPI, 1988–2005
Source: Nakamura and Steinsson (2008b).

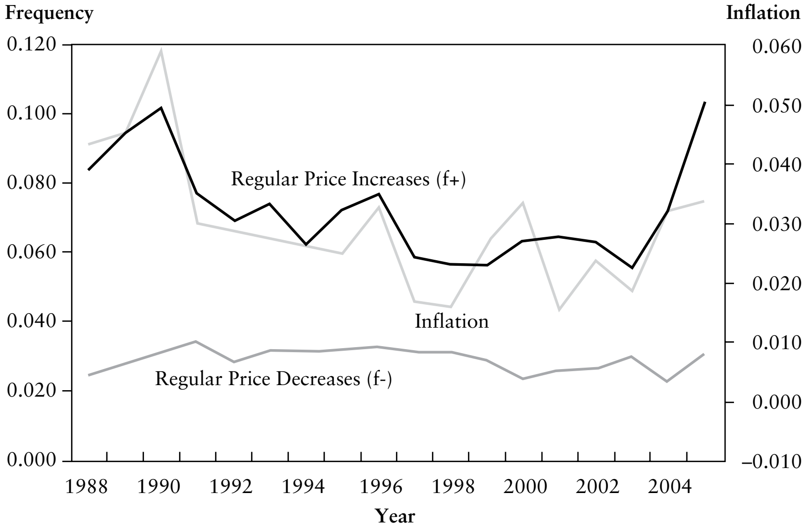

Figure 6.10
Frequency of Regular Price Changes: The Frequency Price Increases (f+) and Price Decreases (f-) in the U.S. CPI, 1988–2005
Source: Nakamura and Steinsson (2008b).

positive—is the central variable in the Calvo model. Approximating $\pi_t + 1 = P_t/P_{t-1} = [\theta(P_t^*/P_t)^{1-\varepsilon} + (1-\theta)]^{1/1-\varepsilon}$ around a zero inflation steady-state, we find that

$$\pi_t \approx \theta[\sum_{j=1}^{\infty}(1-\theta)^j(\log(P_t^*) - \log(P_{t-j}^*))]$$

with the bracketed term being exactly the average size of price changes in the Calvo model. That is, the Calvo model predicts strong comovement between the average size of price changes and inflation. However, as Figure 6.9 shows, there is no strong relationship between inflation and the average size of price increases (m^+) or the average size of price decreases (m^-).

Now, the fact that there is no important comovement of the size of price changes with inflation is revealing about a broader class of models: it should extend to essentially any time-dependent pricing model, not just those with an exogenous and constant adjustment hazard.

*Adjustment frequency moves strongly with inflation.*The fraction of firms that choose to increase prices, f^+, is strongly positively associated with inflation, as shown in Figure 6.10. The fraction of firms reducing prices, f^-, is roughly constant.

Thus, the joint message of Figures 6.9 and 6.10 is that understanding the timing of price adjustments is central to macroeconomics. We need to understand the "extensive margin" of adjustment, not the "intensive margin."

3.3 Further Information on Adjustment Timing

The information underlying Figures 6.9 and 6.10 is based on a particular set of price adjustment definitions and the results are reported at the annual frequency. Klenow and Kryvtsov (2008) also explore the four statistics developed by Nakamura and Steinsson, working with somewhat different definitions of price changes and examining comovement at higher frequencies. Like Nakamura and Steinsson, Klenow and Kryvtsov find that it is the fraction of firms raising prices which correlates most strongly with inflation ($corr(f^+, \pi) = .69$), but they also find that the fraction of firms lowering prices is negatively correlated with inflation (($corr(f^-, \pi) = -.41$)). Finally, they find that there is much smaller correlation of inflation with the magnitudes of price increases ($corr(m^+, \pi) = .19$) or decreases (($corr(m^-, \pi) = -.19$)). Although there is some action on the intensive margin, these more detailed findings suggest that understanding the timing of price adjustments is central.

Thus, the simple model that we presently teach in our first-year classes badly misses out on the key comovement, which is between inflation and adjustment frequency, and instead highlights a less important mechanism, which is a link between the magnitude of price changes and inflation.

Conclusion

The new data on micro prices provides discipline on quantitative macroeconomic model building and also provides challenges to currently popular views about nature of the DSGE models that must be constructed.

The standard model of Calvo (1982), as variously elaborated to provide empirical underpinning for price blocks in quantitative macroeconomic models, fares badly vis-a-vis the micro price data. The available evidence is that price adjustment is relatively frequent, which limits the extent to which the price equations of a macroeconomic model can readily rationalize monetary non-neutrality. A standard extension of the basic model allows firms to costlessly index frequently to the past inflation rate, but not to make frequent fully optimal adjustments. While that "dynamic indexation" model can readily produce both inflation persistence and larger non-neutralities, it is dramatically inconsistent with the micro price data: there is just no evidence that firms actually adjust prices in the manner suggested by the dynamic indexation approach.

Further, there is relatively weak comovement of the magnitude of price changes—the intensive margin of price adjustment—with inflation in recent empirical studies of U.S. micro price data, as would be suggested by most currently popular pricing models. However, there is strong comovement of the fraction of firms that raise prices with the inflation rate. This evidence suggests that it is important to understand when firms choose to adjust prices, i.e., that a central focus for macroeconomic research should be to better understand the extensive margin of price adjustment. When we teach sticky price models to our first-year graduate students, they would be better served by our using an as-yet-undeveloped model that focuses solely on the extensive margin of price adjustment rather than the Calvo model, which focuses solely on the intensive margin.

Notes

1. Of course, there is one basic problem in trying to use *any* model in this class to explain the micro data, as Lucas and Golosov (2007) stress. If there is positive inflation, there is never any reason for a negative price change. But let's suppose that there might be some relatively easy way to fix this, by adding in microeconomic shocks and allowing for adjustment to these.

References

Barro, Robert J. 1977 "Long-term Contracting, Sticky Prices, and Monetary Policy." *Journal of Monetary Economics* 3(3): 305–316.

Bils, Mark and Peter J. Klenow. 2004. "Some Evidence on the Importance of Sticky Prices." *Journal of Political Economy* 112(5): 947–985.

Calvo, Guillermo A. 1983. "Staggered Prices in a Utility Maximizing Framework." *Journal of Monetary Economics* 12(3): 383–398.

Christiano, Lawrence.J., Martin Eichenbaum, and Charles L. Evans. 2005. "Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy." *Journal of Political Economy* 113(1): 1–45.

Dennis, Richard. 2006. "The Frequency of Price Adjustment and New Keynesian Business Cycle Dynamics." Working Paper 2006–22. San Francisco: Federal Reserve Bank of San Francisco.

Eichenbaum, Martin S., and Jonas Fisher. 2007. "Estimating the Frequency of Price Reoptimization in Calvo Style Pricing Models with Dynamic Indexation." *Journal of Monetary Economics* 54(7): 2032–2047.

Fuhrer, Jeff, and George Moore. 1995."Inflation Persistence." *Quarterly Journal of Economics* 110(1): 127–160.

Galí, Jordi, and Mark Gertler. "Inflation Dynamics: A Structural Econometric Analysis." *Journal of Monetary Economics* 44(2): 195–222.

Golosov, Mikhail, and Robert E. Lucas Jr. 2007. "Menu Costs and Phillips Curves." *Journal of Political Economy* 115(2): 171–199.

Hall, Robert, E. 1980. "The Rigidity of Wages and the Persistence of Unemployment." *Brookings Papers on Economic Activit*y 2: 301–335.

Johnston, Michael K. 2007. "Should Macroeconomists Discount Sales?" Working paper. Available at http://michaelkjohnston.com/perm/mkj-sales2007.pdf

King, Robert G., and Alexander L. Wolman. 1996. "Inflation Targeting in a St. Louis Model of the 21st Century." *Review* (Fall): 83–107. St. Louis: Federal Reserve Bank of St. Louis. Available at http://research.stlouisfed.org/publications/review/96/05/9605rk.pdf.

Klenow, Peter J. and Oleksiy Kryvtsov. 2008. "State-Dependent or Time-Dependent Pricing: Does It Matter for Recent U.S. Inflation?" *Quarterly Journal of Economics* 123(3): 863–904.

Mankiw, N. Gregory. 1990. "A Quick Refresher Course in Macroeconomics." *Journal of Economic Literature* 28(4): 1645–1660.

Nakamura, Emi and Jón Steinsson, 2008a. "Five Facts about Prices: A Reevaluation of Menu Cost Models." *Quarterly Journal of Economics* 123(4): 1415–1464.

Nakamura, Emi and Jón Steinsson. 2008b "More Facts about Prices—Supplement to 'Five Facts about Prices.'" Available at http://www.columbia.edu/~en2198/papers.html

Rotemberg, Julio J. 1987. "The New Keynesian Microfoundations." In *NBER Macroeconomics Annual* 2, ed. Stanley Fischer, 69–104. Cambridge, MA: The MIT Press.

Sargent, Thomas J. 1978. "Estimation of Dynamic Labor Demand Schedules Under Rational Expectations." *Journal of Political Economy* 86(6): 1009–1044.

Smets, Frank and Raf Wouters. 2003. “An Estimated Dynamic Stochastic General Equilibrium Model of the Euro Area.” *Journal of the European Economic Association* 1(5): 1123–1175.

Yun, Tack. 1996. “Nominal Price Rigidity, Money Supply Endogeneity, and Business Cycles.” *Journal of Monetary Economics* 37(2): 345–370.