Chapter 22
A New Keynesian Framework of Sticky Prices:
Menu Costs and the Rotemberg Model

Modern New Keynesian sticky-price models are built on a foundation of monopolistic competition. With the basic Dixit-Stiglitz-based framework of monopolistic competition now in our toolkit, we are ready to sketch one of the simplest, yet quantitatively serious, modern sticky-price macroeconomic models.

Our starting point will be exactly the monopolistically-competitive model we just laid out: namely, we will continue assuming that consumers purchase a "retail good" from retail firms; retail firms transform a continuum [0,1] of differentiated wholesale products into the retail good by operating a Dixit-Stiglitz aggregation technology; and each producer of a differentiated wholesale product wields some monopoly power over its output, which renders it a price-setter instead of a price-taker. However, rather than assuming price-setting is costless, as we did in our introduction to monopolistic competition, we will now assume that there are some *costs associated directly with the act of price-setting*. In particular, when a wholesale firm in period t decides to set a (nominal) price different from the one it charged in period t-1, it must pay a cost of re-setting its price. This cost is completely independent of any costs associated with the physical production process itself. That is, this cost is completely unrelated to any wage costs or capital investment costs that a wholesale firm pays. In the language used in the field, this pure cost of price-adjustment is a **menu cost.**

At both an empirical level and a theoretical level, the nature of these menu costs deserves some discussion. As such, we begin there; we then proceed to sketch one of the most commonly-used (and simplest) versions of a sticky-price model featuring menu costs and analyze some of its implications.

Menu Costs

The predominant core of any modern theory of price stickiness is that the very act of changing prices itself entails costs. Indeed, this is also the simplest of theories of price stickiness. The basic idea is most easily illustrated with an example. Suppose a restaurant is considering increasing the prices of some or all of the items on its menu. Presumably, price increases are being considered because they would be in the best interest of the restaurant – that is, the price increases would presumably increase total profit. To make the example concrete, suppose that at current demand conditions, if the restaurant could costlessly change its prices, \$1000 in extra total profit would be generated. However, in order to implement its price changes, the restaurant would have to print new menus. If the restaurant had to pay its printer \$2000 to print new menus, it clearly is not in the interest of the firm to change its prices – indeed, changing prices would cause total profit to decrease by \$1000, so the firm instead chooses to hold its prices steady.[186] This example suggests the general terminology: a **menu cost** is a cost incurred by a firm due to the price-adjustment process itself – in our example, it is literally the price of printing new menus.

In the Appendix, we study this example further in order to determine under what circumstances a firm would be willing to incur this type of menu cost. Leaving the details to the Appendix, here we only mention that analysis of this type of menu cost is a bit cumbersome due to its **discrete** nature. That is, in the example just laid out, the \$2000 fee the restaurant must pay to the printer is (presumably) invariant to the magnitude of the price change: the firm would have to pay the \$2000 fee whether it decided to double all its prices or raise all its prices by only 10 percent (because the price of ink and printing doesn't really depend on what numbers are being printed, say). Such a discrete (or fixed) nature of menu costs in many situations may sound plausible.

Adopting a bit broader notion of what a "menu cost" is, though, might lead us to think that "costs of price adjustment" might sometimes depend on the magnitude of the price change itself. For example, if the "costs of price adjustment" include things such as concerns about upsetting customers, it is likely that these costs are larger the larger is the price change. This aspect of menu costs is admittedly a softer notion than the physical cost of "printing a menu," but it is often implicit in what macroeconomists have meant and continue to mean by the term.[187]

For this reason, we will adopt not a discrete (fixed) view of menu costs, but rather a continuous (variable) view of menu costs. It also turns out that a continuous view of menu costs is much more tractable in the context of macroeconomic analysis (for the usual reasons that continuous functions are readily amenable to our standard calculus tools). A simple, continuous, specification of menu costs is to assert that a firm's total cost of price adjustment depends in a convex – specifically, a quadratic – manner on the magnitude of the price change it implements.

In all of what follows, we will suppose that the *real* costs to wholesale firm j of changing the nominal price it charges is

[186] To illustrate the basic issues at stake here, we are purposely ignoring the timing of "when" these potential extra profits would accrue. The answer to the question "Is it worth it to pay the menu cost?" depends on whether the \$1000 in total extra profit is a present-discounted value of *all current and future* profits the firm will ever earn after the price change or whether the \$1000 is the increase in *per-period profits* the firm will enjoy after the price change.

[187] The profession has only lately begun to try to more seriously grapple with the issue of what some of these softer, more social "costs" of changing prices might be. Thus far, empirical evidence regarding this (limited though it still is) leads the development of theoretical frameworks with which to think about this.

$$\frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}}-1\right)^2.$$

This **quadratic price-adjustment cost function** is quite common in modern New Keynesian models.[188] If wholesaler j decides to set $P_{jt} = P_{jt-1}$, clearly it pays no menu cost (because the quadratic term disappears). Instead, if it chooses to set a P_{jt} different from P_{jt-1}, it does incur a menu cost; moreover the cost is larger the further from the "reference level" P_{jt-1} it chooses to set P_{jt}. Due to the quadratic nature of the cost function, price-adjustment costs are symmetric with respect to both price increases and price decreases.[189] The parameter $\psi > 0$ is simply a scale parameter; it is particularly convenient to include because if we set $\psi = 0$, we return exactly to the flexible-price (i.e., zero menu cost) case.

Finally, note that we emphasized that the total price-adjustment cost $\frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}}-1\right)^2$ is a *real* cost – that is, it is denominated in terms of real consumption baskets (and, here, the consumption "basket" is the "retail good" that consumers purchase). If we wish to express the total price adjustment cost in nominal units, we must multiply by the nominal price of the retail consumption basket, which is P_t. Hence, the total price-adjustment cost incurred by wholesale firm j in nominal terms is $\frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}}-1\right)^2 P_t$ -- note carefully the subscripts on the various P's.

Our main task in what follows is to embed into our previous model of monopolistic competition these quadratic costs of price adjustment.

Retail Firms

The representative retail goods firm is identical to that described in our introduction to monopolistic competition; refer there for a review of the details. Most important to keep in mind for what follows is that we are continuing to assume that nominal prices of retail

[188] It was first proposed as a tractable way of incorporating stickiness of prices into modern macroeconomic models in an influential paper in the early 1980's: Rotemberg, Julio J. 1982. "Sticky Prices in the United States." *Journal of Political Economy*, Vol. 90, p. 1187-1211.

[189] Whether nominal prices are as sticky on the downward side as on the upward side is clearly an assumption we can question. Introspection about the world likely suggests that customer "anger" over a given magnitude price decrease (if, after all, this quadratic specification is meant to capture effects such as that) is a lot smaller (or perhaps altogether absent) than a given magnitude price increase. Our Rotemberg-inspired price-adjustment cost specification clearly cannot account for this.

goods are determined in a perfectly-competitive environment, which means, among other things, that there are **no** menu costs associated with price changes of retail goods.

As a brief reminder of the basics, then, once again a retail firm uses the Dixit-Stiglitz aggregator,

$$y_t = \left[\int_0^1 y_{it}^{1/\varepsilon} di \right]^{\varepsilon},$$

which takes as inputs the various wholesale products y_{it}'s, $i \in [0,1]$, and yields as output the retail good y_t. As before, the period-t nominal profit function of the representative retail firm is

$$P_t y_t - \int_0^1 P_{it} y_{it} di,$$

which is simply its total revenue net of its total costs (recall our assumption that purchases of wholesale goods are the only cost items for a retail firm). Again as before, inserting the aggregator technology from above, we can re-express the profit function as

$$P_t \left[\int_0^1 y_{it}^{1/\varepsilon} di \right]^{\varepsilon} - \int_0^1 P_{it} y_{it} di.$$

Profit maximization by the retail firm leads to a demand function for any wholesale good j

$$y_{jt} = \left(\frac{P_{jt}}{P_t} \right)^{\frac{\varepsilon}{1-\varepsilon}} y_t,$$

once again exactly as before.

Thus, because costs of price adjustment do not impinge directly on retail firms, absolutely nothing regarding either the retail firm's optimization problem or solution is new.

Wholesale Firms

Where things are different is at the level of wholesale producers. We continue to focus on just the activities and decisions of one particular wholesale producer, producer j (recall that we have a continuum [0,1] of wholesale producers). We continue to maintain two assumptions from earlier: first, there are zero fixed costs of production; second, the per-unit production cost of each unit of intermediate output is identical regardless of the scale of production. Thus, just as before, these assumptions imply that the wholesale firm's *marginal cost of production is invariant to the quantity that it chooses to produce.*

Wholesale firms now also face a second type of cost, separate from costs associated with physical production; namely, the quadratic menu costs. Given this, the nominal profit function of wholesale firm j in period t can be expressed as

$$P_{jt} y_{jt} - P_t mc_{jt} y_{jt} - \frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2 P_t,$$

which is nothing more than total (nominal) revenues minus total (nominal) costs. As before, from here on, we will assume that the marginal production cost function is identical across wholesale firms, which allows us to drop the index j from mc.

We know from our study of the basic, flexible-price monopolistic competition model that we ultimately want to solve for the wholesale firm's optimal pricing decision regarding P_{jt}. In the flexible-price model, it was sufficient to simply maximize (after appropriately substituting in the firm's demand function) the expression above, which is the *period-t* nominal profits of wholesale firm j. However, the menu cost introduces a dynamic element into the wholesale firm's profit-maximization problem, an aspect completely absent in the flexible-price benchmark. Indeed, this dynamic element to a wholesale firm's optimal pricing decision should be thought of as *the* fundamental difference between any sticky-price view of the world and a flexible-price view of the world.

As usual, we want to analyze things from the perspective of the very beginning of period t. The term above is period-t nominal profits. However, consider also the wholesale firm's nominal profits in period t+1:

$$P_{jt+1} y_{jt+1} - P_{t+1} mc_{t+1} y_{jt+1} - \frac{\psi}{2}\left(\frac{P_{jt+1}}{P_{jt}} - 1\right)^2 P_{t+1}.$$

Notice that nominal profits in period t+1 **depend in part on the nominal price P_{jt}** charged in period t. This is due to the presence of P_{jt} as part of the period t+1 cost of price adjustment: apart from any direct physical costs of production, a particular price P_{jt} chosen for period t has consequences, all else equal, for both the menu costs the wholesale firm will incur in period t as well as the menu costs the firm will have to incur in period t+1. This is why a sticky-price view of the world introduces a dynamic – i.e., across multiple time periods – element into firms' profit-maximization problems.

Thus, in deciding its optimal period-t nominal price P_{jt}, wholesale firm j must take into account not only its period-t profits, but rather its *discounted* profits across both period t and t+1. Specifically, the relevant objective it must maximize is

$$P_{jt}y_{jt} - P_t mc_t y_{jt} - \frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2 P_t + \frac{\beta}{1+\pi_{t+1}}\left[P_{jt+1}y_{jt+1} - P_{t+1}mc_{t+1}y_{jt+1} - \frac{\psi}{2}\left(\frac{P_{jt+1}}{P_{jt}} - 1\right)^2 P_{t+1}\right],$$

in which, note, we have applied a modified form of the subjective discount factor β to period t+1 profits. Specifically, the discount factor required here is a **nominal** discount factor, rather than a real discount factor. The discount factor β we used in our study of the representative consumer is a real discount factor – it discounts one-period-ahead utils and goods. Our profit functions are specified in nominal terms. Thus, in addition to just β, we must also discount by the one-period-ahead nominal discount factor, P_t/P_{t+1}, which by our standard definitions, is simply $1/(1+\pi_{t+1})$.[190]

Next, recall that a monopolist (in our analysis, monopolistic competitor j) **takes as given the demand function it faces** when making its profit-maximizing choices. Thus, we must make use of the demand function for wholesale good j that emerges from the retail firm's profit-maximization problem. Substituting in the demand function for wholesale good j **in both period t and in period t+1,** we can re-express wholesale firm j's now-dynamic profit function as

$$\begin{aligned}
&P_{jt}\left(\frac{P_{jt}}{P_t}\right)^{\frac{\varepsilon}{1-\varepsilon}} y_t - P_t mc_t \left(\frac{P_{jt}}{P_t}\right)^{\frac{\varepsilon}{1-\varepsilon}} y_t - \frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}} - 1\right)^2 P_t \\
&+ \frac{\beta}{1+\pi_{t+1}}\left[P_{jt+1}\left(\frac{P_{jt+1}}{P_{t+1}}\right)^{\frac{\varepsilon}{1-\varepsilon}} y_{t+1} - P_{t+1}mc_{t+1}\left(\frac{P_{jt+1}}{P_{t+1}}\right)^{\frac{\varepsilon}{1-\varepsilon}} y_{t+1} - \frac{\psi}{2}\left(\frac{P_{jt+1}}{P_{jt}} - 1\right)^2 P_{t+1}\right].
\end{aligned}$$

This is the dynamic profit function that wholesale firm j seeks to maximize, and it must set its period-t price in order to do so.

As before, to make our algebra a bit more transparent, we can combine some of the P_{jt} terms; specifically, rewrite the dynamic profit function as

[190] Apart from this technical issue, we are thus in effect assuming here that wholesale firms discount profits at the same discount rate as the representative consumer. An underlying justification for this may be that, ultimately, it is "consumers/individuals" that own – via, say, stock markets – firms and thus own claims to their profits. As long as the intertemporal incentives of firm managers are aligned with those of the firm's shareholders (which can sometimes be a questionable assumption), this is a useful way of articulating such a linkage.

$$P_{jt}^{\frac{1}{1-\varepsilon}}P_t^{\frac{\varepsilon}{\varepsilon-1}}y_t - P_{jt}^{\frac{\varepsilon}{1-\varepsilon}}P_t^{\frac{2\varepsilon-1}{\varepsilon-1}}mc_t y_t - \frac{\psi}{2}\left(\frac{P_{jt}}{P_{jt-1}}-1\right)^2 P_t$$
$$+\frac{\beta}{1+\pi_{t+1}}\left[P_{jt+1}\left(\frac{P_{jt+1}}{P_{t+1}}\right)^{\frac{\varepsilon}{1-\varepsilon}}y_{t+1} - P_{t+1}mc_{t+1}\left(\frac{P_{jt+1}}{P_{t+1}}\right)^{\frac{\varepsilon}{1-\varepsilon}}y_{t+1} - \frac{\psi}{2}\left(\frac{P_{jt+1}}{P_{jt}}-1\right)^2 P_{t+1}\right].$$

Proceeding by brute force, the first-order condition of this expression (which is, after all, still simply wholesale firm j's dynamic profit function) with respect to P_{jt} is

$$\frac{1}{1-\varepsilon}P_{jt}^{\frac{\varepsilon}{1-\varepsilon}}P_t^{\frac{\varepsilon}{\varepsilon-1}}y_t - \frac{\varepsilon}{1-\varepsilon}P_{jt}^{\frac{2\varepsilon-1}{1-\varepsilon}}P_t^{\frac{2\varepsilon-1}{\varepsilon-1}}mc_t y_t$$
$$-\psi\left(\frac{P_{jt}}{P_{jt-1}}-1\right)\frac{P_t}{P_{jt-1}} + \frac{\beta\psi}{1+\pi_{t+1}}\left(\frac{P_{jt+1}}{P_{jt}}-1\right)\frac{P_{t+1}}{P_{jt}}\frac{P_{jt+1}}{P_{jt}} = 0$$

In this first-order condition, terms arise through the period $t+1$ price-adjustment cost because a choice for P_{jt} has consequences for, among other things, the menu costs that will be incurred later (in period $t+1$), a point we mentioned above.

An observation to make about this first-order condition is that if $\psi = 0$, meaning there are no menu costs, we have exactly the same first-order condition as in the simple flexible-price Dixit-Stiglitz model.[191] This is the sense in which we meant above that it was convenient to allow for the scale parameter ψ in the first place – it allows us to capture as a special case the flexible-price environment by setting $\psi = 0$. The sticky-price case of course features $\psi > 0$.

This first-order condition is essentially the **New Keynesian Phillips Curve**; however, there are a few more conceptual issues and technical details to step through before we can see it in a cleaner form.

Symmetric Equilibrium

In the first-order condition we just derived, the price of wholesale good j, P_{jt}, and the price of the retail good, P_t, obviously both appear. In laying out the Dixit-Stiglitz and now Rotemberg models, we obviously relied a great deal on the separation into wholesale and retail sectors. Indeed, we have needed this separation in order to articulate first the idea of price-*setting* firms and now of price-setting firms that incur costs of nominal price adjustment.

[191] Verify this yourself.

Now, we are going to once again blur the distinction between "wholesale goods" and "retail goods" and again just speak of "goods." The reason for doing so is that, in the end, macroeconomic analysis is concerned mostly with aggregates. From the point of view of the GDP measurement that most countries perform, there is no distinction between "wholesale goods" and "retail goods" – it is just "baskets" that are being measured. We can (re-)capture this idea by now imposing, in the first-order condition we just derived, **symmetry** between wholesale and retail goods. Mathematically, symmetry is achieved by now simply dropping all the *j* subscripts.[192] Dropping all the *j* subscripts blurs the distinction between wholesale goods and retails goods. Now re-label all goods as just "baskets" or *the* good produced, consumed, invested, etc. in the economy.

Imposing this symmetry assumption in the first-order condition we just derived, then, we have

$$\frac{1}{1-\varepsilon}P_t^{\frac{\varepsilon}{1-\varepsilon}}P_t^{\frac{\varepsilon}{\varepsilon-1}}y_t-\frac{\varepsilon}{1-\varepsilon}P_t^{\frac{2\varepsilon-1}{1-\varepsilon}}P_t^{\frac{2\varepsilon-1}{\varepsilon-1}}mc_t y_t$$
$$-\psi\left(\frac{P_t}{P_{t-1}}-1\right)\frac{P_t}{P_{t-1}}+\frac{\beta\psi}{1+\pi_{t+1}}\left(\frac{P_{t+1}}{P_t}-1\right)\frac{P_{t+1}}{P_t}\frac{P_{t+1}}{P_t}=0$$

We can now collapse many terms in this expression. First, note that $P_t^{\frac{\varepsilon}{1-\varepsilon}}P_t^{\frac{\varepsilon}{\varepsilon-1}}=P_t^{\frac{-\varepsilon}{\varepsilon-1}}P_t^{\frac{\varepsilon}{\varepsilon-1}}=P_t^0=1$, and, similarly, $P_t^{\frac{2\varepsilon-1}{1-\varepsilon}}P_t^{\frac{2\varepsilon-1}{\varepsilon-1}}=P_t^{\frac{1-2\varepsilon}{\varepsilon-1}}P_t^{\frac{2\varepsilon-1}{\varepsilon-1}}=P_t^0=1$. Thus, the above expression becomes

$$\frac{1}{1-\varepsilon}\left[1-\varepsilon mc_t\right]y_t-\psi\left(\frac{P_t}{P_{t-1}}-1\right)\frac{P_t}{P_{t-1}}+\frac{\beta\psi}{1+\pi_{t+1}}\left(\frac{P_{t+1}}{P_t}-1\right)\frac{P_{t+1}}{P_t}\frac{P_{t+1}}{P_t}=0\,.$$

Next, use the definition of inflation to make the substitutions $1+\pi_t=P_t/P_{t-1}$ and $1+\pi_{t+1}=P_{t+1}/P_t$ to get

$$\frac{1}{1-\varepsilon}\left[1-\varepsilon mc_t\right]y_t-\psi\pi_t(1+\pi_t)+\frac{\beta\psi}{1+\pi_{t+1}}\pi_{t+1}(1+\pi_{t+1})^2=0\,,$$

which obviously simplifies a bit to

[192] An *extremely* important technical point to understand is that we can eliminate the *j* subscripts *only after having computed the wholesale firm's first-order condition.* If we had dropped the subscript *j* before computing this first-order condition, the entire analysis would be rendered moot from the start. Thus, symmetry must be essentially the "last" step of the analysis.

$$\frac{1}{1-\varepsilon}\left[1-\varepsilon mc_t\right]y_t-\psi\pi_t(1+\pi_t)+\beta\psi\pi_{t+1}(1+\pi_{t+1})=0.$$

This expression is the **New Keynesian Phillips Curve,** and it is the critical component of the modern New Keynesian framework.

Interpreting the New Keynesian Phillips Curve

What the New Keynesian Phillips Curve (abbreviated NKPC) articulates is that when firms are making optimal pricing decisions (and, of course, if those pricing choices are subject to menu costs), the period-t inflation rate (which is a consequence of firms' settings for P_{jt}, which in our symmetric equilibrium is identical to P_t) is linked to the period-t marginal cost of production *as well as the rate of inflation that will occur in period* $t+1$, π_{t+1}.[193]

Two aspects of the NKPC set it apart from the "classic" Phillips Curve you recall from basic macroeconomics. First, the classic Phillips Curve was a relationship between only period-t events – the period $t+1$ inflation rate played no role in it. The inclusion of the future rate of inflation in the NKPC is due to the fact that – drawing on basic insights of the Real Business Cycle view of macroeconomics – firms in New Keynesian theory are viewed to be explicitly *dynamic* institutions, and price-setting is viewed to be explicitly a *dynamic* act. As we have stressed in many ways, dynamically-optimal (i.e., across multiple time periods) decision-making is at the heart of modern macroeconomic theory. This aspect of macroeconomic thinking has been inherited by the New Keynesian school of thought from the RBC theorists.

Second, the classic Phillips Curve was a relationship between the period-t inflation rate and the period-t *unemployment rate*. Thus, even ignoring for a moment the presence of π_{t+1} in the NKPC, what the NKPC articulates is not a contemporaneous relationship between inflation and unemployment, but rather a relationship between inflation and the *marginal costs of production*. Specifically, the NKPC posits that there is, *ceteris paribus*, a positive relationship between mc_t and π_t.

Employment – labor input – is typically the most important input into firms' production processes. Hence, the classic Phillips Curve can be viewed as stating that the more intensively firms use labor, the higher are the prices they set (due to some "pass-through" of costs to prices), and hence the higher the inflation rate an economy (in, essentially, the same type of symmetric equilibrium we are considering here) experiences. That is, the classic Phillips Curve can be stated as articulating a *positive* linkage between employment and inflation. Of course, because employment and unemployment are

[193] Or, introducing some more realism, if there is uncertainty about the future, the expected inflation rate in period $t+1$.

inversely related, the Phillips Curve can also be stated, as it typically is, as articulating a *negative* linkage between *un*employment and inflation.

The NKPC takes a somewhat broader view of the relationship between the intensity of firms' input usage and the inflation rate. The marginal cost of production is a broader measure of the intensity of firms' input usage than is simply the employment rate. Firms' marginal costs of course include employment costs, but also include the costs of any and all other inputs, most notably capital and raw materials. Thus, cost pressures can stem from employment costs, capital costs, or the costs of raw materials. What the NKPC articulates is that, again *ceteris paribus*, a rise in firms' production costs *for any reason*, will lead to inflationary pressure. The classic Phillips Curve essentially only articulates that employment-cost pressures (and the unemployment rate is *one* measure of such pressures) have consequences for inflation.

Discussion

The fundamental economic forces that determine inflation are completely different in the New Keynesian view compared to the flexible-price (RBC-style) view. In the New Keynesian view, *purposeful* price-setting decisions on the part of firms, subject to the menu costs they face, is the basic determinant of inflation. In contrast, in the RBC view, there are fundamentally no price-*setters* to begin with. Rather, equilibrium prices simply "arise" out of the forces of supply and demand – prices "simply" clear markets, and all decision-makers, be they consumers or firms, take them as given.

The view of price-*setting* firms, of course, does not require a menu-cost view of the world. Indeed, the basic Dixit-Stiglitz framework, not the Rotemberg framework, is what captures the idea of purposeful price-setting by firms. It is sticky prices, though, that potentially gives monetary policy some lever over the economy. Whether or not prices are sticky – or, a bit more deeply, the precise reasons why some prices are sticky – is still a quite unresolved issue.

Finally, you may be wondering where, in the end, the "stickiness" of prices lies in the Rotemberg model. After all, each wholesale firm *is* able to change the price that it charges in every period t, $t+1$, $t+2$, … -- that is, it is never "forbidden" from changing its nominal price.[194] The stickiness stems simply from the menu cost. Say in the absence of any menu costs, a firm would have chosen to increase its price by 20 percent. With menu costs, it will be partially deterred from this pricing strategy because the costs of changing

[194] Unlike in a popular alternative New Keynesian model of sticky prices, the Calvo model, in which each period some fraction of firms is simply *assumed* to be completely unable to change its nominal price – we could say that in some periods, some firms face an *infinite* menu cost of changing prices. The Calvo model is more cumbersome to use than the Rotemberg model and yet delivers very similar predictions on several counts. Over the last five to ten years, however, the Calvo model has overtaken the Rotemberg model as the preferred sticky-price framework for serious quantitative work, in both academic and policy institutions.

prices are a convex function of the magnitude of the price change. Thus, instead of changing its price by 20 percent in a given time period, it will prefer to “smooth out” the price change, raising it by some proportion (less than 20 percent) in one period and by some other proportion (again, less than 20 percent) in future periods. Loosely speaking, then, a Rotemberg-type menu cost makes it *sub*optimal for a firm to move around its price by large magnitudes; instead, it will prefer to gradually change its price over time – price stickiness.