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Globalization and Inflation Dynamics
The Impact of Increased Competition

Argia M. Sbordone

10.1 Introduction

The policy debate about the macroeconomic effects of globalization has centered on two main themes: that globalization has contributed to bring down U.S. inflation, and that it has affected the sensitivity of inflation to output fluctuations. Several recent policymakers' speeches have addressed the issue of whether more intense competition, generated by the increase in trade experienced since the 1990s, has changed the role of domestic factors in shaping the inflation process. Chairman Bernanke (2006), for example, has underlined how the dependence of factor markets on economic conditions abroad might have reduced the market power of domestic sellers, how the pricing power of domestic producers might have declined, and how lower import prices both of final and intermediate goods might have contributed to maintain overall inflation at low levels. Similarly, President Yellen (2006) and Governor Kohn (2006) have discussed several direct and indirect impacts of more global markets on U.S. inflation.

In this chapter I explore how globalization might have impacted U.S. inflation by using the analytical framework of the new-Keynesian model of inflation dynamics. Within this framework, I focus in particular on the effects that an increase in market competition generated by an increase in trade might have on the sensitivity of inflation to real marginal costs of production.

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The relationship between inflation and marginal cost is a key determinant of the overall "slope" of the new-Keynesian Phillips curve (NKPC), which links the dynamics of inflation to the level of economic activity. In the price setting model most often used to derive the NKPC (the one based on the contribution by Calvo [1983]), this relationship depends primarily on the frequency of price changes, but it is also affected by strategic complementarity in price setting. It is this last mechanism that provides a way of formalizing the "globalization" argument, according to which the increase in the openness of the economy has affected the sensitivity of inflation to output variations.

I depart here from the assumption of constant elasticity of substitution among differentiated goods, which is typically made in the Calvo model, and adopt instead a specification where the elasticity is function of the firm's relative market share. This modification implies that changes in the importance of trade that affect relative market shares affect in turn the elasticity of demand faced by firms, hence their desired markups. Through this channel they may ultimately have an impact on the elasticity of aggregate inflation to real marginal costs and on the slope of the Phillips curve.

To preview my results: I find that an increase in the number of goods traded is indeed able to generate the sort of real rigidities that may lead to a change in the slope of the Phillips curve. The sign of the change, however, depends on how fast the elasticity of substitution among goods increases; hence, different assumptions about the curvature of the demand function may lead to different answers. For large enough increases in the number of goods traded, the slope of the Phillips curve is in general declining. However, the evidence on U.S. trade patterns so far provides little ground to assume that we are yet in the declining portion of the curve.

There are a number of caveats to these results. In particular, the elasticity of inflation to marginal cost is only one of the determinants of the slope of the Phillips curve—the overall response of inflation to output (or output gap)—and its increase or decline does not necessarily imply that the change in the overall response has the same sign. However, the elasticity of inflation to marginal cost is arguably the component most affected by variations in the degree of market competition and it is the one brought up in policy discussions of the effects of global competition on the "pricing power" of domestic firms. Hence a study of implications of global competition should be centered on this elasticity. I return to this point in the conclusion.

The chapter is organized as follows. Section 10.2 overviews existing evidence about the change in the slope of the Phillips curve and discusses the ensued debate. Section 10.3 analyzes the channels through which the increase in trade that characterizes globalization may affect the dynamics of inflation. Section 10.4 introduces the analytical framework that is used to pin down these effects, and section 10.5 adapts the framework to analyze the effects of firms' entry on the dynamics of price adjustments. Section

10.6 evaluates the quantitative impact of trade increase on the marginal cost slope of the Phillips curve, and section 10.7 concludes.

10.2 Has the Slope of the Phillips Curve Changed?

The policymakers' concerns over a change in the slope of the Phillips curve in recent years derive from its role in assessing the cost of disinflation. A flatter Phillips curve carries the implication that, for a given degree of inflation persistence, reducing inflation involves a higher "sacrifice ratio" than otherwise; namely, it requires enduring a longer period of unemployment above the natural rate for every desired percentage point of reduction in inflation. On the other hand, as noted by Mishkin (2007), a flatter Phillips curve also implies that an overheated economy will tend to generate a smaller increase in inflation.

Most of the empirical analyses supporting the policymakers' concerns address the issue of the flattening of the Phillips curve in the context of traditional "accelerationist" Phillips curves. Roberts (2006) and Williams (2006), for example, estimate smaller Phillips curves' slopes in samples covering the post-1984 period. Williams in particular analyzes samples with moving starting points—from 1980:1 to 1999:4, but with a fix end point (2006:4)—and finds evidence of a flatter curve and a higher sacrifice ratio in the samples that start in the 1990s relative to those estimated in the full sample. However, he also finds that in the more recent samples the unit sum restriction on the lag coefficients, which defines the accelerationist curve, is violated. Furthermore, when in these samples the lag coefficients are left unconstrained, the estimate of the slope coefficient indeed increases.

An alternative source of evidence that the slope of the Phillips curve has declined in more recent samples is provided by estimates in the context of general equilibrium models. Boivin and Giannoni (2006), for example, estimate that the coefficient of marginal cost in a new-Keynesian Phillips curve declines from .011 to .008 in the post-1984 period; Smets and Wouters (2007), in a similar general equilibrium model, report that the estimated interval between price changes is higher in the 1984 to 2004 sample relative to the 1966 to 1979 period, which implies that the slope declined in the more recent period.

While the just-cited studies aim at relating the change in the inflation-output trade-off to the change in monetary policy that took place in the early 1980s, in a recent Bank for International Settlements (BIS) study Borio and Filardo (2007) link instead variations in the slope of the Phillips curve to globalization. Specifically, they estimate a traditional Phillips curve for many countries over the two periods 1980 to 1992 and 1993 to 2005, and document that in the more recent period there has been both a decline in the autoregressive coefficient—hence a decline in inflation persistence—and a decline in the slope, hence a drop in the sensitivity of inflation to domestic output gap. For the United States, in particular, the authors report a decline in the estimated coefficient of lagged inflation from .92 to .82 across the two samples, and a decline in the elasticity of inflation to output gap from .13 to .09. They take this evidence as the starting point of an investigation of a "global slack" hypothesis, according to which the decline in the sensitivity of inflation to domestic measures of output gap is explained by the fact that global measures of demand pressure have become in the later period the main driving force of inflation dynamics.

A successor study (Ihrig et al. 2007) finds that the purported support for the global slack hypothesis is not robust to the specification of the measures of global slack. For example, the study finds that variables such as domestic output time the ratio of trade to gross domestic product (GDP), and import prices time the ratio of imports to GDP do not have statistically significant coefficients. The study, however, does not dispute the evidence that the Phillips curve appears to have flattened since the 1990s; it contests the interpretation that this is indeed an effect of globalization. Overall, the authors in fact conclude that the estimated effect of foreign output gaps is in general insignificant, and that there is no evidence that the trend decline in the sensitivity of inflation to domestic output is due to globalization; moreover, they find no increase in the sensitivity of inflation to import prices.

An International Monetary Fund (IMF) study (2006) also estimates traditional inflation regressions where the coefficient on the slack variable interacts with measures of central bank credibility and openness of the economy. The study estimates a negative coefficient on the interaction term between domestic output gap and trade openness, measured by the share of non-oil imports in GDP, and interprets this result as evidence that the increase in trade has contributed to the decline of the slope of the Phillips curve. The study, however, examines the group of advanced economies as a whole, and does not present results for the United States alone. Finally, in the context of a similar traditional Phillips curve estimated for the United States, Ball (2006) allows interaction of the output coefficient with trade, and finds only a modest effect.

In this chapter I do not estimate the slope of the Phillips curve, but propose instead a simple theoretical framework to analyze the quantitative importance of globalization effects on such a slope. Specifically, I modify the well-known new-Keynesian model of inflation dynamics to identify the channels through which an increase in market competition can generate a flattening of the Phillips curve.

10.3 Channels of Globalization Effects on Inflation

The basic channel emphasized both in policy debates and empirical studies as a potential carrier of globalization effects on inflation dynamics is trade integration, which—especially when accompanied by policy incentives—would bolster competition. Increased competition, the argument goes, creates two effects: a direct effect of containment of costs, by restraining increases in workers' compensations and reducing real import prices, and a second, indirect effect of creating pressure to innovate, which contributes to increasing productivity. Higher productivity in turn further lowers production costs: if markups are constant, lower production costs reduce the pressure on prices. But the margins that firms are willing to charge over their costs might be reduced as well, moderating the extent of price increases.

To understand how these effects work, it is useful to decompose the relation between consumer price inflation and domestic output (the one typically analyzed in empirical studies) in three distinct parts. First, there is the relation between consumer price index (CPI) inflation and domestic inflation. In an open economy, consumer price inflation reflects the price dynamics of goods produced both domestically and abroad that are consumed at home. Second, there is the relation between domestic inflation and the marginal cost of production, and finally, the relationship between the marginal cost of production and domestic output.

The central relationship that describes how variations in marginal cost translate into fluctuations in domestic prices is the one most likely affected by an increase in competition.

When analyzed through the lens of the new-Keynesian approach to the construction of a Phillips curve, the strength of this relationship depends on a number of factors. The first is the frequency of price revisions: the longer prices are kept fixed, the more nominal disturbances translate into real effects, rather than aggregate inflation. This is referred to as the nominal rigidity component. The second component is the sensitivity of the desired firms' price to marginal costs versus other prices. If price setters take into account other firms' prices when they set their own price, then the presence of even a small number of firms that do not change their price induces flexible-price firms to change their price by a lesser amount. A third component is the sensitivity of marginal costs to the output of the firm (versus its sensitivity to the average marginal cost): when marginal costs of the price setter are increasing in its own output, the desired price increase is smaller because the firm takes into account the decline in marginal cost due to the loss in demand incurred for the price increase. Finally, the pricing decisions are affected by the sensitivity of the firm's own output to its relative price; namely, by how elastic is the demand curve of the individual producer. The last three components are commonly referred to as "strategic complementarity" or "real rigidity" channels.[1]

Both nominal and real rigidities are known to be important in assessing the size of the "slope" of the new-Keynesian Phillips curve with respect to marginal costs. They have been analyzed in theoretical works and explored

1. See the discussion of those terms in Woodford (2003 chap. 3).

in empirical studies aiming at reconciling estimated "slopes" with reasonable degrees of nominal rigidity.[2]

In this chapter, I focus on the real rigidity component and analyze how it can be affected by the openness of the economy through the increase in competitiveness generated by an increase in the number of goods traded in the economy.

To do this I borrow from the new trade literature, and in particular from a recent contribution by Melitz and Ottaviano (2008), who present a model of trade with monopolistic competition and firm heterogeneity to study the effect of trade liberalization on productivity and markups. The authors show that import competition induces a downward shift in the distribution of markups across firms. A key element of their model is the dependence of the elasticity of demand upon the relative size of the market. This setting has been used in general equilibrium models by Bilbiie, Ghironi, and Melitz (2006a, 2006b) to study endogenous entry as a propagation of business cycles and efficiency properties of these models, adopting a framework of flexible prices.

Here I study instead a model of staggered prices. I consider a monopolistically competitive market where there is a fixed entry cost and a given distribution of firms. A reduction in individual firms' production costs moves up the firms' distribution curve, making it profitable for more firms to enter the market. The resulting increase in the variety of goods traded increases the overall degree of competition: this is captured in the model by making the demand elasticity, and hence, the markup, vary with the number of goods that are traded. Variable markups in turn impact the price setting process and the dynamics of the relationship between inflation and marginal cost.

My focus is specifically on how the process of new entries and the interaction of firms in the price setting process affect the relationship between aggregate inflation and marginal costs. I will not discuss the other two components of the CPI inflation-domestic output relationship that I described—the relation between domestic and CPI inflation and the relation between marginal cost and domestic output. These relationships obviously matter for the assessment of the overall effect of openness on the Phillips curve's slope, and an explicit modeling of the Phillips curve in open economy may as well illustrate that its slope is lower than that of the closed economy.[3] Nevertheless, understanding the channels through which market entry changes the degree of real rigidity, and how that may emphasize or reduce the inflation-output trade-off, is of primary importance.

Similarly, I will not discuss effects of globalization on inflation of the kind

2. See literature cited later.

3. Several aspects of the difference between open and closed economy are discussed by Woodford (chapter 1 in this volume).

argued by Rogoff (2003, 2006)—that in a global environment central banks have less incentive to inflate the economy. Although this lower incentive is another effect of the increased competitiveness of the economy, it is related to central banks' incentives,[4] rather than to the market mechanisms to which I am interested in here.

10.4 A Structural Framework

The Calvo model of staggered prices provides a useful framework to disentangle the various theoretical channels that compose the inflation-marginal cost relationship. Because the baseline model is well known, here I only summarize its main features to set the stage for the generalizations that I discuss next.

The model has a continuum of monopolistic firms, indexed by i, which produce differentiated goods, also indexed by i, over which consumers' preferences are defined. Firms produce with a constant returns to scale technology and have access to economy-wide factor markets. The optimal consumption allocation determines the demand for each differentiated good, $c_t(i)$, as

$$c_t(i) = C_t \left(\frac{p_t(i)}{P_t} \right)^{-\theta}, \tag{1}$$

for $\theta > 1$; here $p_t(i)$ is the individual good i price, and C_t indicates aggregate consumption, defined by the constant elasticity of substitution aggregator of Dixit and Stiglitz:

$$C_t = [\int c_t(i)^{(\theta-1)/\theta}\, di]^{\theta/(\theta-1)}, \tag{2}$$

and P_t is the corresponding aggregate price (the minimum cost to buy a unit of the aggregate good C_t): $P_t = [\int p_t(i)^{1-\theta} di]^{1/(1-\theta)}$. The model further assumes random intervals between price changes: in every period, only a fraction (1 – α) of the firms can set a new price, independently of the past history of price changes, which will then be kept fixed until the next time the firm is drawn to change prices again. By letting α vary between 0 and 1, the model nests assumptions about the degree of price stickiness from perfect flexibility ($\alpha = 0$) to complete price rigidity (the limit as $\alpha \rightarrow 1$). The expected time between price changes is then $1/(1 - \alpha)$.

The pricing problem of a firm that revises its price in period t is to choose the price $p_t(i)$ that maximizes its expected stream of profits

$$E_t \left\{ \sum_{j=0}^{\infty} Q_{t,t+j} \mathsf{P}_{t+j}(i) \right\}, \tag{3}$$

4. The increase in competitiveness on one hand reduces the monopoly wedge that determines the inflation bias of the central bank, and on the other makes prices and wages more flexible, reducing the real effects of unanticipated monetary policy, hence the gain from inflating.

where time t profits $\mathsf{P}_t(i)$ are a function $\mathsf{P}\,(p_t(i), P_t, y_t(i), Y_t; \Gamma_t)$; $y_t(i)$ is firm's output, defined by (1), $Q_{t,t+j}$ is a stochastic discount factor, and the variable Γ_t stands for all other aggregate variables. The first-order condition for the optimal price is

$$E_t\left\{\sum_{j=0}^{\infty} Q_{t,t+j}\mathsf{P}_1\,(p_t^*, P_{t+j}, y_{t+j}(i), Y_{t+j}; \Gamma_{t+j})\right\} = 0, \tag{4}$$

where the evolution of aggregate prices is

$$P_t = [(1-\alpha)p_t^{*1-\theta} + \alpha P_{t-1}^{1-\theta}]^{1/(1-\theta)}. \tag{5}$$

Log-linearizing these two equilibrium conditions around a steady state with zero inflation, with usual manipulations, one obtains the familiar form of inflation dynamics as function of expected inflation and real marginal costs s_t

$$\pi_t = \zeta\hat{s}_t + \beta E_t\pi_{t+1}, \tag{6}$$

where a hat indicates the log-deviation from a nonstochastic steady state, β is the steady-state value of the discount factor, and the "slope" is defined as[5]

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}. \tag{7}$$

In this baseline framework, the extent of the nominal rigidity determines how marginal costs translate into inflation fluctuations. In order to introduce potential channels of transmission of marginal cost pressures of the kind discussed previously the model needs to be generalized.

10.4.1 The Inflation/Marginal Cost Relation: Some Generalizations

Generalizations of the baseline model can lead to changes in the nominal rigidity component of the slope or introduce some form of real rigidity of the kind discussed previously by adding new terms to expression (7).

One instance in which the nominal rigidity term is modified, despite maintaining an exogenous probability of changing prices, occurs when one allows for a nonzero steady-state inflation. In this case the expression for inflation dynamics is derived as a (log)-linear approximation of the model equilibrium conditions (4) and (5) around a steady state characterized by positive, rather than zero inflation, as is the case in the baseline model. Such an approximation modifies the terms in the discount and the rigidity coefficient in the slope (9). As first shown by Ascari (2004), in such a case the slope coefficient would be:

$$\zeta = \frac{(1-\alpha\beta\overline{\Pi}^{\theta})(1-\alpha\overline{\Pi}^{\theta-1})}{\alpha\overline{\Pi}^{\theta-1}}, \tag{8}$$

5. Throughout the chapter I will use the term "slope" to indicate the elasticity of inflation to marginal cost, rather than to output.

where $\overline{\Pi}$ denotes the gross trend inflation rate. The slope in this case depends not only upon the primitives of the Calvo model, the probability of changing prices $1 - \alpha$, and the elasticity of demand, but also upon the steady-state level of inflation. In this case the NKPC has also a richer dynamic, because it includes additional forward-looking terms, unless particular forms of indexation are postulated.[6]

A further modification of the nominal rigidity component is obtained by replacing the assumption of a constant probability of price reoptimization with a state-dependent probability (see Dotsey, King, and Wolman 1999).

The generalizations that provide a more direct channel through which the competitive effect of more global markets integration can alter the Phillips curve's slope are those that introduce real rigidity factors in the slope coefficient. Such modifications were at first introduced with the purpose of reconciling empirical estimates of the slope with a degree of nominal rigidity more in line with that documented in firms' surveys.[7] In fact, for any given degree of nominal rigidity, the existence of strategic complementarity lowers the slope or, alternatively, a given empirical estimate of the slope is consistent with a lower degree of nominal rigidity.

Assuming, for example, that some or all factor markets are firm-specific implies that the marginal cost of supplying goods to the market is not equal for all goods at any specific point in time. In such cases firms' marginal costs depend not only on economy-wide factors, but also on the firm's own output[8] and, for any given increase in marginal cost, this dependence makes the desired price increase smaller. Returning to a baseline case with zero steady-state inflation, the slope ζ in these cases becomes

$$\zeta = \frac{(1 - \alpha\beta)(1 - \alpha)}{\alpha} \frac{1}{1 + \theta s_y}, \tag{9}$$

where the strategic complementarity term $1/(1+\theta s_y)$ depends upon the demand elasticity θ, which measures the sensitivity of the own output of the firm to its relative price, and the sensitivity of the firm's marginal cost to its own output, s_y. The parameter s_y in turn depends on other model

6. If one assumes that nonreoptimized prices are indexed at least partly to trend inflation, this additional dynamic is eliminated and the slope is unaffected by the steady-state inflation $\overline{\Pi}$. Models with positive trend inflation can be generalized to the case of time varying steady-state inflation; in this case the model describes the dynamics of inflation deviations from a time varying trend: $\hat{\pi}_t = \ln(\Pi_t/\overline{\Pi}_t)$. Cogley-Sbordone (2008) estimate a NKPC with time varying trend inflation. Ireland (2007) and Smets and Wouters (2003), among others, estimate general equilibrium models in the new-Keynesian literature, allowing for a time varying trend inflation; their assumptions, however, deliver a time-invariant slope.

7. For evidence from survey data see, for example, Blinder et al. (1998).

8. Sbordone (2002) discusses this case. A more sophisticated model assumes that capital is endogenously determined, and its limited reallocation is due to the existence of adjustment costs. Woodford (2005) discusses this model, and concludes that the hypothesis of a fixed capital is a good enough approximation. For another empirical application, see Eichenbaum and Fisher (2007).

assumptions: for example, when labor is traded in an economy-wide labor market but capital is firm specific and therefore cannot be instantaneously reallocated across firms, a constant returns to scale production function implies that s_y is equal to the ratio of the output elasticities with respect to capital and labor.[9] In a more general case where labor markets as well are firm-specific, the parameter s_y is a composite parameter that includes also the elasticity of the marginal disutility of work with respect to output increases (Woodford 2003).

Another extension is the case in which each firm's desired markup over its marginal cost depends upon the prices of other firms. Because the desired markup depends on the firm's elasticity of demand, a variable desired markup can be obtained by assuming a variable demand elasticity. Modeling this case thus requires departing from the standard Dixit-Stiglitz aggregator. For example, the aggregator proposed in the macro literature by Kimball (1995) allows for the elasticity of substitution between differentiated goods to be a function of their relative market share.

Kimball was interested in a variable elasticity of demand to generate countercyclical movements in the firm's desired markup, and sufficient real rigidity to make a model of sticky prices plausible (i.e., without having to assume too large a percentage of firms keeping prices constant for long periods of time). His objective was to generate more flexible demand functions, particularly "quasi-kinked" demand functions, characterized by the property that for the firm at its normal market share, it is easier to lose customers by increasing its relative price than to gain customers by lowering its relative price. By making the elasticity of demand depend upon the firm's relative sales, Kimball's preferences generate another kind of strategic complementarity that amplifies the effect of nominal disturbances and, everything else equal, reduces the size of the Phillips curve's slope.[10] Such property has spurred new research on various implications of the assumption of a nonconstant elasticity of demand. Dotsey and King (2005) use a specific functional form for the Kimball aggregator in a calibrated DSGE model to study the dynamic response of inflation and output to monetary shocks in the context of a state-dependent pricing model. Levin, Lopez-Salido, and Yun (2006) adopt the Kimball specification to analyze the interaction of strategic complementarity and steady-state inflation. In empirical work, Eichenbaum and Fisher (2007) use the same specification to pin down a realistic estimate of the frequency of price reoptimization in the Calvo model. Finally, in the context of an open economy model, Gust, Leduc, and Vigfusson (2007) extend these preferences to the demand of home produced and imported goods, to show that with strategic complementarity

9. For example, with a Cobb-Douglas production technology $s_y = a/(1 - a)$, where $1 - a$ is the output elasticity with respect to labor.

10. See the discussion of these preferences in the context of models with price rigidities in Woodford (2003).

lower trade costs reduce the pass-through of exchange rate movements to import prices.

Departing from the constant demand elasticity assumption along the lines of Kimball, the consumption aggregate in (2) is replaced by an aggregate C_t, implicitly defined by

$$\int_{\Omega} \psi\left(\frac{c_t(i)}{C_t}\right) di = 1, \tag{10}$$

where $\psi(\cdot)$ is an increasing, strictly concave function, and Ω is the set of all potential goods produced (a real line). With this notation the Dixit-Stiglitz aggregator corresponds to the case where $\psi\ (c_t\ (i)/C_t) = (c_t\ (i)/C_t)^{(\theta-1)/\theta}$ for some $\theta > 1$. With an aggregator function of the form (10) one can show[11] that the Calvo model implies an inflation dynamics of the baseline form, where the slope (considering again for simplicity the case of an approximation around a steady state with zero inflation) becomes

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\,\frac{1}{1+\bar{\theta}(\bar{s}_y+\bar{\varepsilon}_\mu)}. \tag{11}$$

Here $\bar{\theta}$ is the steady-state value of the firm's elasticity of demand, which is now a function $\theta(x)$ of the firm's relative sales (denoted by x); $\bar{\varepsilon}_\mu$ is the steady-state value of the function $\varepsilon_\mu(x)$ that represents the elasticity of the markup function $\mu(x)$, which also depends on the firm's relative sales, and $\bar{s}_y$ is the steady-state value of the elasticity of the firm's marginal cost with respect to its own sales. The interactions of the new variables in the strategic complementarity term $1/1 + \bar{\theta}(\bar{s}_y + \bar{\varepsilon}_\mu)$ determines to what extent the slope ζ differs from that of the baseline case.

Expression (11) formalizes all the channels through which globalization may affect the strength of the relationship between inflation and marginal costs that I discussed in section 10.3. It shows that the slope coefficient depends upon a number of variables: (a) the frequency of price revisions, represented by the coefficient α: less frequent price revisions (a higher value of α) correspond to lower ζ; (b) the sensitivity of the desired firm's price to marginal cost versus other prices, the term $\bar{\varepsilon}_\mu$; (c) the sensitivity of marginal cost to the firm's own output, the term $\bar{s}_y$; and (d) the sensitivity of the firm's own output to the relative price, $\bar{\theta}$.[12] The higher these sensitivities, the lower the slope (ζ).

The Calvo model enriched with these modifications is now a suitable framework for discussing the effects of globalization: the task is to relate the factors that drive the value of the slope to the increase in trade openness, that is one of the characteristics of a more global environment. This is what

11. See the later derivation for the specific parametrization considered.

12. In addition, in approximations that allow for positive steady-state inflation, the slope is possibly affected by the level of trend inflation, which may interact with the demand elasticity, as in (8).

I consider next. Leaving aside the issue of whether globalization affects the frequency of price adjustments, and more generally the nominal rigidity term, in the next section I focus on the effects of an increase in trade on the strategic complementarity term.

10.5 The Effect of Firms' Entry

10.5.1 Kimball Preferences with a Variable Number of Goods

I extend Kimball's (1995) model to an environment where the number of traded goods is variable. The model implies that the elasticity of demand depends on the firm's relative output share: by relating this share to the number of goods traded, the steady-state elasticity of demand becomes a function of the number of traded goods in steady state. This implies that the degree of strategic complementarity varies with the number of traded goods; hence, so does the slope of the inflation-marginal cost curve.

I assume that households' utility is defined over an aggregate C_t of differentiated goods $c_t(i)$, defined implicitly by (10), where $\psi(.)$ is an increasing, strictly concave function, and I also assume that $\psi(0) = 0$. If the set of goods that happen to be sold is $[0, N]$, then $c_t(i) = 0$ for all $i > N$; and C_t satisfies[13]

$$\int_0^N \psi\left(\frac{c_t(i)}{C_t}\right) di = 1. \tag{12}$$

The elasticity of demand, in this setup, is defined as a function

$$\theta(x) = -\frac{\psi'(x)}{x\psi''(x)}, \tag{13}$$

where x indicates the relative market share of the differentiated goods. In Kimball's formulation the elasticity of demand is lower for those goods that sell more because their relative price is lower. Accordingly, the desired markup pricing over costs is as well a function of the market share:

$$\mu(x) = \frac{\theta(x)}{\theta(x) - 1}. \tag{14}$$

The optimal consumption allocation across goods is the solution to the following problem:

$$\min_{\{c_t(i)\}} \int_0^N p_t(i)c_t(i)di \quad \text{s.t.} \quad \int_0^N \psi\left(\frac{c_t(i)}{C_t}\right) di = 1.$$

13. Note that under this assumption changes in the number of goods available for sale involve no change in preferences as the utility function is independent of N. This contrasts with Benassy's (1996) generalization of the Dixit-Stiglitz preferences, that depend on the value N.

The first-order conditions for this problem are

$$p_t(i) = \frac{1}{\Lambda_t C_t}\psi'\left(\frac{c_t(i)}{C_t}\right), \tag{15}$$

for each $i \in [0, N]$, where Λ_t is the Lagrange multiplier for the constraint. The solution to this minimization problem gives the demand for each good i as

$$c_t(i) = C_t\psi'^{-1}(p_t(i)\Lambda_t C_t), \tag{16}$$

where Λ_t is implicitly defined by the requirement that

$$\int_0^N \psi(\psi'^{-1}(p_t(i)\Lambda_t C_t))\, di = 1. \tag{17}$$

Expression (17) defines a price index $\tilde{P}_t \equiv 1/\Lambda_t C_t$ for any set of prices $\{p_t(i)\}$, independent of C_t. We can then write the demand curve for good i as

$$y_t(i) = Y_t\psi'^{-1}\left(\frac{p_t(i)}{\tilde{P}_t}\right). \tag{18}$$

Note that the aggregate "price" $\tilde{P}_t$ is not in general the same as the conventional price index, which here is defined, as in the case of Dixit-Stiglitz preferences, as the cost of a unit of the composite good; that is,

$$P_t = \frac{1}{C_t}\int_0^N p_t(i)c_t(i)di = \int_0^N p_t(i)\psi'^{-1}\left(\frac{p_t(i)}{\tilde{P}_t}\right)di, \tag{19}$$

where the second equality follows from (18). Both P_t and $\tilde{P}_t$, however, are homogeneous of degree one functions in $\{p_t(i)\}$.

10.5.2 Steady State with Symmetric Prices

I am interested in the properties of the demand curve in a steady state with symmetric prices $p_t(i) = p_t$ for all i. In this case, it follows from (12) that the relative demand $c_t(i)/C_t$ is equal to

$$\frac{c_t(i)}{C_t} = \psi^{-1}\left(\frac{1}{N}\right), \tag{20}$$

for all i, and from (15):

$$\tilde{P}_t = \frac{p_t}{\psi'(\psi^{-1}(1/N))}. \tag{21}$$

From the definition of P_t in (19) it also follows that

$$P_t = p_t\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]. \tag{22}$$

The elasticity of demand in such a steady state, denoted by θ, is

$$\bar{\theta} = -\frac{\psi'(x)}{x\psi''(x)}, \tag{23}$$

where $x = \psi^{-1}(1/N)$ denotes the relative share in the symmetric steady state. Note how this elasticity differs from the case of the Dixit-Stiglitz aggregator, where the elasticity of demand is a constant $\theta(x) = \theta$ for all x. Here the demand elasticity depends upon the relative market share of the good, and its value in steady state, $\bar{\theta}$, is a function of the number of goods traded in steady state, N. I am interested in seeing *how* this steady state elasticity $\bar{\theta}$ varies with N. The extent of this variation depends on how the elasticity function $\theta(x)$ varies with x.[14]

The assumptions made so far do not have implications for the sign of $\theta'(x)$. However, if we assume, as Kimball (1995) does, that the function $\theta(x)$ is decreasing in x, since $\psi^{-1}(1/N)$ is decreasing in N, it follows that $\bar{\theta}$ is *increasing* in N. This is in line with the general intuition that the more goods are traded in a market, the more likely it is for the demand to decrease more in response to a small increase in prices.

As $\bar{\theta}$ varies with the number of goods traded, so does the desired markup of prices over costs, evaluated in steady state. I define the steady-state desired markup as $\bar{\mu} \equiv \bar{\theta}/(\bar{\theta} - 1)$: if $\bar{\theta}$ is increasing in N, then the steady-state desired markup is decreasing in N. For what it is discussed later, it is also important to evaluate the extent to which the markup itself, as defined in (14), varies with the relative sales, and therefore with the number of traded goods.

The elasticity of the mark-up function to the firm's market share is

$$\varepsilon_{\mu}(x) = \frac{\partial \log \mu(x)}{\partial \log x} = \frac{x\mu'(x)}{\mu(x)}, \tag{24}$$

which, evaluated at $x = \psi^{-1}(1/N)$, is denoted as[15]

$$\bar{\varepsilon}_{\mu} = \frac{x\mu'(x)}{\mu(x)}.$$

The elasticity $\bar{\varepsilon}_{\mu}$ determines how much $\bar{\mu}$ varies for a small variation in N.[16] Since

$$\frac{\partial \log \mu}{\partial \log N} = \frac{\partial \log \mu}{\partial \log x} \bullet \frac{\partial \log x}{\partial \log N} = \bar{\varepsilon}_{\mu} \cdot \frac{\partial \log x}{\partial \log N},$$

14. The function θ(•) could also be expressed as a function of the relative price, rather than the market share, as in Gust, Leduc, and Vigfusson (2007).

15. Note that this elasticity could alternatively be defined as $\varepsilon_{\mu}(x) = -\varepsilon_{\theta}(x)/[\theta(x) - 1]$, where $\varepsilon_{\theta}(x) = (\partial \log \theta(x))/(\partial \log x)$.

16. The value of $\bar{\varepsilon}_{\mu}$ is important to determine the degree of strategic complementarity in price setting, for small departures from the uniform-price steady state (see Woodford 2003).

and since $1/N = \psi(x)$,

$$\frac{\partial \log N}{\partial \log x} = -\frac{x\psi'(x)}{\psi(x)} = -N\psi^{-1}\left(\frac{1}{N}\right)\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right),$$

we have that

$$\frac{\partial \log \mu}{\partial \log N} = \frac{-\bar{\varepsilon}_{\mu}}{N\psi^{-1}(1/N)\,\psi'(\psi^{-1}(1/N))}.$$

The elasticity of μ with respect to N has therefore the opposite sign of the elasticity $\bar{\varepsilon}_{\mu}$. In turn, we can determine how $\bar{\varepsilon}_{\mu}$ must vary with N by considering how $\varepsilon_{\mu}(x)$ varies with x. Because we can argue that log μ is a convex function of log x,[17] it follows from definition (24) that $\varepsilon_{\mu}(x)$ is an increasing function of x: we can then conclude that $\bar{\varepsilon}_{\mu}$ is a *decreasing* function of N.

Finally, it can be shown that the steady-state sensitivity of the firm's marginal cost to its own output, $\bar{s}_y$, is also a function of N. This elasticity depends upon assumptions about the form of the production function and about consumer preferences, which I have not spelled out yet. The nature of the dependence of $\bar{s}_y$ on N, however, can be illustrated by way of some simple assumptions. Let the production function of firm i be

$$y_t(i) = h_t(i)^{1-a} - \Phi, \tag{26}$$

where $h(i)$ is labor hours and Φ is a fixed cost. This leads to a labor demand function

$$h_t(i) = (y_t(i) + \Phi)^{1/(1-a)}. \tag{27}$$

Assuming an economy-wide labor market, with nominal wage W_t, the total cost of production of firm i is $W_t h_t(i)$, and its real marginal cost is

$$s_t(i) = \frac{MC_t}{P_t}(y_t(i); \Gamma_t) = \frac{1}{1-a}\frac{W_t}{P_t}(y_t(i) + \Phi)^{a/(1-a)}, \tag{28}$$

where Γ_t indicates aggregate variables that enter into the determination of firms' marginal costs. The elasticity of the marginal cost to firm's own output is then

$$s_y(y_t(i); \Gamma_t) = \frac{a}{1-a}\left[\frac{y_t(i)}{y_t(i) + \Phi}\right].$$

Evaluating this elasticity at a steady state with symmetric prices gives

17. This follows from the hypothesis that $\theta'(x) < 0$, so that $\mu(x)$ is an increasing function of x. In this case it is not possible for log μ to be a concave function of log x, because this would require log μ to be negative for positive and small enough x. But this cannot happen, no matter how large $\theta(x)$ gets for small x. If log μ must be convex, at least for small values of x, it is convenient to assume that it is a globally convex function of log x.

(29) $$\bar{s}_y = \frac{a}{1-a}\left[\frac{xY}{xY+\Phi}\right] = \frac{a}{1-a}\left[\frac{x}{x+\Phi/Y}\right],$$

where again $x = \psi^{-1}(1/N)$ and Y denotes the steady state of aggregate output. Since both x and Y are functions of N, so is $\bar{s}_y$: whether it increases or decreases with N depends upon whether x or $1/Y$ decreases more sharply with N. I discuss this point with some detail in the appendix.

We have thus established that the steady-state elasticity of demand $\bar{\theta}$ is *increasing* in N, while the elasticity of the desired markup evaluated in steady-state $\bar{\varepsilon}_\mu$ is *decreasing* in N; how the elasticity of the marginal cost to firm's own output $\bar{s}_y$ depends on N is established numerically in the quantitative exercise that I conduct in section 10.6. The overall role of N in the price/marginal cost relationship is examined next.

10.5.3 The Price Setting Problem

The firms' pricing problem in this setup generalizes the problem considered in section 10.4. Price setting firms at t choose their price $p_t(i)$ to maximize the following expected string of profits over the life of the set price:

$$E_t\left\{\sum_{j=0}^{\infty}\alpha^j Q_{t,t+j}\left[p_t(i)Y_{t+j}\psi'^{-1}\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right) - \mathsf{C}\left(Y_{t+j}\psi'^{-1}\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right);\Gamma_{t+j}\right)\right]\right\},$$

where $\mathsf{C}(\cdot)$ is the firm's cost function; generalizing (4), the first-order condition (FOC) for this problem are

$$E_t\sum_{j=0}^{\infty}\left(\alpha^j Q_{t,t+j}P_{t+j}Y_{t+j}x\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right)\left[\theta\left(x\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right)\right)-1\right]\right.$$
$$\left.\times\left[\frac{p_t(i)}{P_{t+j}} - \mu\left(x\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right)\right)s\left(Y_{t+j}\psi'^{-1}\left(\frac{p_t(i)}{\tilde{P}_{t+j}}\right);\Gamma_{t+j}\right)\right]\right) = 0,$$

where the relative share is $x(P/\tilde{P}) \equiv \psi'^{-1}(P/\tilde{P})$. The elasticity of demand $\theta(x)$ and the markup function $\mu(x)$ are defined in (13) and (14), and $s(y_t(i);\Gamma_t)$ is the real marginal cost of producing quantity $y_t(i)$ in period t, given aggregate state Γ_t, which is unaffected by the pricing decision of firm i.[18]

Log-linearizing the FOC around a steady state with zero inflation one obtains:

(30) $$E_t\sum_{j=0}^{\infty}(\alpha\beta)^j\left[\left(\hat{p}_t^* - \sum_{k=1}^{j}\pi_{t+k}\right) + \bar{\varepsilon}_\mu\bar{\theta}\left(\hat{p}_t^* - \sum_{k=1}^{j}\tilde{\pi}_{t+k} + \log\left(\frac{P_t}{\tilde{P}_t}\right) - K\right)\right.$$
$$\left. + \bar{s}_y\bar{\theta}\left(\hat{p}_t^* - \sum_{k=1}^{j}\tilde{\pi}_{t+k} + \log\left(\frac{P_t}{\tilde{P}_t}\right) - K\right) - \hat{s}_{t+j}\right] = 0,$$

18. Note that the real marginal cost is defined as the ratio $MC_t(i)/P_t$, not the ratio $MC_t(i)/\tilde{P}_t$.

where p^* denotes the optimal price and $\hat{p}_t^* = \log(p_t^*/P_t) - \log(p/P)\,|_{ss}$; $\pi_t \equiv \Delta \log P_t$, $\tilde{\pi}_t \equiv \Delta \log \tilde{P}_t$; $K \equiv \log(P/\tilde{P})\,|_{ss}$; $\bar{s}_y = (\partial \log s_t(i))/(\partial \log y_t(i))\,|_{ss}$, $\hat{s}_t = \log s(Y_t; \Gamma_t) - \log s(Y; \Gamma)\,|_{ss}$, and the steady-state values follow from previous calculations. In particular, from (22)

$$\log\left(\frac{p^*}{P}\right)|_{ss} = -\log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right];$$

from (22) and (21)

$$\log\left(\frac{P}{\tilde{P}}\right)|_{ss} = \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)\right],$$

and, since $\log s \equiv \log[(MC/p)(p/P)]$ it follows that:

$$\log s(Y; \Gamma)\,|_{ss} = -\log \bar{\mu} - \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]. \tag{31}$$

Log-linearizing the dynamics of the price indices, one gets, for $\tilde{P}_t$

$$\int_0^N \left(\log p_t(i) - \log \tilde{P}_t - \log\left[\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)\right]\right) di = 0,$$

which, to a first-order approximation, gives

$$\log \tilde{P}_t = \frac{1}{N}\int_0^N \log p_t(i)di - \log\left[\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)\right].$$

For P_t, as defined in (19), we have

$$\int_0^N \Bigg\{\log p_t(i) - \log P_t + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right] + \frac{\psi'(x)}{x\psi''(x)}\left(\log p_t(i) - \log \tilde{P}_t - \log\left(\frac{p(i)}{\tilde{P}}\right)|_{ss}\right)\Bigg\} di = 0,$$

which, to a first-order approximation, implies

$$\log P_t = \frac{1}{N}\int_0^N \log p_t(i)di + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]. \tag{32}$$

Therefore, to a first-order approximation,

$$\log\left(\frac{P_t}{\tilde{P}_t}\right) = \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right] + \log\left[\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)\right] \equiv K,$$

and therefore

$$\tilde{\pi} = \pi_t.$$

Under the assumption of Calvo staggered prices, we can also write the expression for the general price level (32) as

$$\log P_t = \frac{1}{N}\left(\alpha \int_0^N \log p_{t-1}(i)di\right) + (1-\alpha)\log p_t^* + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]$$

$$= \alpha \log P_{t-1} + (1-\alpha)\left\{\log p_t^* + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]\right\}$$

$$= \alpha \log P_{t-1} + (1-\alpha)(\hat{p}_t^* + \log P_t),$$

where the last equality follows from the definition of $\hat{p}_t^*$. We then have

$$\alpha \log P_t = \alpha \log P_{t-1} + (1-\alpha)\hat{p}_t^*. \tag{33}$$

10.5.4 The Slope of the NKPC

The log-linearized equilibrium conditions (30) and (33) can now be expressed, respectively, as

$$E_t \sum_{j=0}^{\infty}(\alpha\beta)^j\left[\left(1 + \bar{\theta}(\bar{\varepsilon}_\mu + \bar{s}_y)\left(\hat{p}_t^* - \sum_{k=1}^{j}\pi_{t+k}\right) - \hat{s}_{t+j}\right)\right] = 0 \tag{34}$$

and

$$\pi_t = \frac{1-\alpha}{\alpha}\hat{p}_t^*. \tag{35}$$

With typical transformations, (34) and (35) imply again an expression for inflation of the form

$$\pi_t = \zeta\hat{s}_t + \beta E_t\pi_{t+1},$$

where, however, the slope is now defined as in (11) and, more explicitly, as

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\,\frac{1}{1 + \bar{\theta}(N)\,[\bar{\varepsilon}_\mu(N) + \bar{s}_y(N)]}. \tag{36}$$

Through the functions $\bar{\varepsilon}_\mu$, $\bar{s}_y$, and $\bar{\theta}$ the slope ζ depends upon the number of goods traded in steady state.[19] As previously discussed, $\bar{\theta}$ is increasing in N while $\bar{\varepsilon}_\mu$ is decreasing in N, and the elasticity $\bar{s}_y$ will be shown to be decreasing in N as well. Thus, the net effect of a change in the steady-state value of traded goods on the slope depends on the relative size of the response of all these variables. This is what I analyze next.

19. It should also be observed that N has an additional effect on inflation dynamics that can be seen by rewriting (6) as

$$\pi_t = \zeta(\log s_t - \log \bar{s}) + \beta E_t\pi_{t+1}.$$

The steady-state value of the marginal cost is a function of the steady-state markup $\bar{\mu}$ and the steady-state relative price p/P, which are both functions of N: $\log \bar{s}(N) = -\log \bar{\mu}(N) - \log [N\psi^{-1}(1/N)]$.

10.6 Quantitative Effect of Trade Increase on the Phillips Curve Slope

In order to evaluate the quantitative impact of the trade increase on the slope ζ, I need to parametrize the function $\psi(x)$. First, I choose a functional form along the lines of Dotsey and King (2005), setting:

$$\psi(x) = \frac{1}{(1+\eta)\gamma}[(1+\eta)x - \eta]^{\gamma} - \frac{1}{(1+\eta)\gamma}(-\eta)^{\gamma},$$

where the constant term is chosen to satisfy the condition $\psi(0) = 0$ stated before.

For this specification of $\psi(x)$ the demand function (16) is

$$\frac{c_t(i)}{C_t} = \frac{1}{1+\eta}\left[\left(\frac{p_t(i)}{\tilde{P}_t}\right)^{1/(\gamma-1)} + \eta\right],$$

a sum of a constant and a Dixit-Stiglitz term, where the parameters γ and η control the elasticity and the curvature of the function. I discuss later the calibration of the parameters γ and η for the quantitative exercise.

Using the derivations of the previous section, I can now write explicit expressions for the variables that enter the slope of the Phillips curve and show how they depend on N in a steady state with symmetric prices. The steady-state relative share x in (20) is

(37) $$x \equiv \psi^{-1}\left(\frac{1}{N}\right) = \frac{1}{1+\eta}\left\{\left[\frac{(1+\eta)\gamma}{N} + (-\eta)^{\gamma}\right]^{1/\gamma} + \eta\right\};$$

the steady-state elasticity (23) is

(38) $$\bar{\theta} = \frac{\eta - (1+\eta)\psi^{-1}(1/N)}{(\gamma-1)(1+\eta)\psi^{-1}(1/N)},$$

and the elasticity of markup (25) is the following function of N:

$$\bar{\varepsilon}_{\mu} = \frac{\eta(\gamma-1)(1+\eta)\psi^{-1}(1/N)}{[\eta - (1+\eta)\psi^{-1}(1/N)][\eta - \gamma(1+\eta)\psi^{-1}(1/N)]}.$$

Finally, the steady-state markup is

$$\bar{\mu} = \frac{\eta - (1+\eta)\psi^{-1}(1/N)}{\eta - \gamma(1+\eta)\psi^{-1}(1/N)}.$$

Plugging numerical values for the parameters η and γ in these expressions allows us to determine the quantitative effect of an increase in N on the slope of the inflation-marginal cost function.

Unfortunately, the literature does not offer much guidance for what are the most plausible values for η and γ. One possibility is to choose a combination of these two parameters that guarantees a desired value for the markup (hence, for the demand elasticity) in a steady state where the relative share x is equal to 1. Dotsey and King (2005), for example, set $\gamma = 1.02$, and determine η so that $\bar{\theta}(1) = 10$ (or a markup of 11 percent), which gives $\eta = -6$.[20] Levin, Lopez-Salido, and Yun (2006), in order to have a markup of 16 percent in their baseline case, choose instead a lower value of 7 for the elasticity $\bar{\theta}(1)$, and set $\eta = -2$. In an open economy model Gust, Leduc, and Vigfusson (2007) choose η to match their model's implications for the volatility of output, and then select γ to give a 20 percent markup pricing in steady state (and $\bar{\theta}(1) = 6$). This implies setting $\gamma = 1.15$ and $\eta = -1.87$. The larger is η in absolute value, the more concave is the demand function. This is shown in figure 10.1 for the case in which $\bar{\theta}(1) = 7$, and in figure 10.2 for the case of $\bar{\theta}(1) = 10$. In each figure the line with circles corresponds to $\eta = 0$, which is the Dixit-Stiglitz case of constant elasticity. The other two lines are Kimball's demand functions with different curvatures. The value of the parameters η and γ are indicated in the figures.

I start the quantitative exercise by considering the parametrization of Levin, Lopez-Salido, and Yun (2006), and then evaluate the case of a lower initial markup (higher demand elasticity), according to the parametrization of Dotsey and King (2005). The steady-state elasticity $\bar{\theta}(1)$ assumed in these studies is relatively in line with estimates of the Dixit-Stiglitz elasticity obtained from macro data.[21] In micro data, however, estimates of the elasticity of substitution are very sensitive to the level of aggregation. Broda and Weinstein (2006), for example, estimate elasticities for a large number of goods at three different levels of aggregation, and find higher elasticities for more disaggregated sectors. That means that varieties are closer substitutes when disaggregation is higher. Although their estimated elasticities cover a wide range of values, the median elasticity for the period 1972 to 1988 ranges from 2.5 to 3.7, depending on the aggregation level.[22] This suggests to investigate as well the effects of parametrizations of the aggregator function based on a much lower value of the demand elasticity in the initial steady state. Identifying this state with the period 1972 to 1988, which represents a preglobalization period, I consider parameter values for η and γ that satisfy $\bar{\theta}(1) = 3$. Figure 10.3 shows the demand functions for this case, in a manner analogous to figures 10.1 and 10.2.[23]

20. It follows from (23) that for $x = 1$: $\bar{\theta} = -1/((\gamma - 1)(1 + \eta))$.

21. For example, in Cogley-Sbordone (2008) we estimate a Calvo model with a Dixit-Stiglitz specification and time varying inflation trend. Using aggregate data on inflation, unit labor costs, output, and interest rates we estimate an elasticity of about 10.

22. It is also interesting to note that their estimated elasticities across each disaggregation group appear to slightly decrease, rather than increase, in the 1990 to 2001 period versus the 1972 to 1988. Their interpretation is that imported goods have become more differentiated over time.

23. Whatever the assumed values of $\bar{\theta}(1)$, I choose for η only two alternative values, –3 and –2, as reported in the figures: more negative values would make the demand curve too kinked. Given η, a value for γ follows from expression (23) evaluated at $x = 1$.

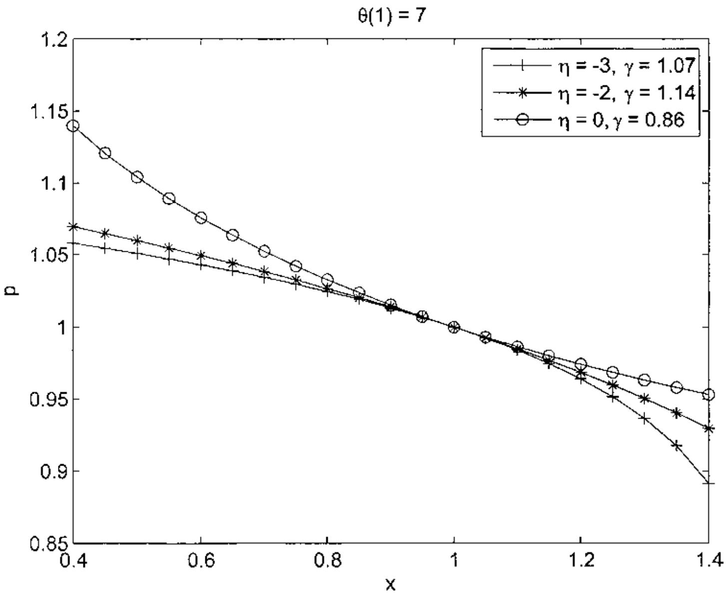

Fig. 10.1 Demand functions for various parametrizations; $\overline{\theta}(x) = 7$ at $x = 1$

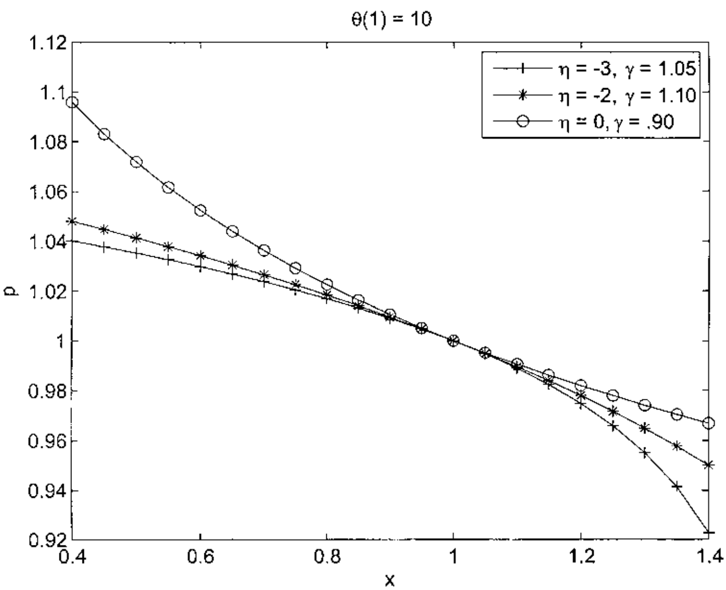

Fig. 10.2 Demand functions for various parametrizations; $\overline{\theta}(x) = 10$ at $x = 1$

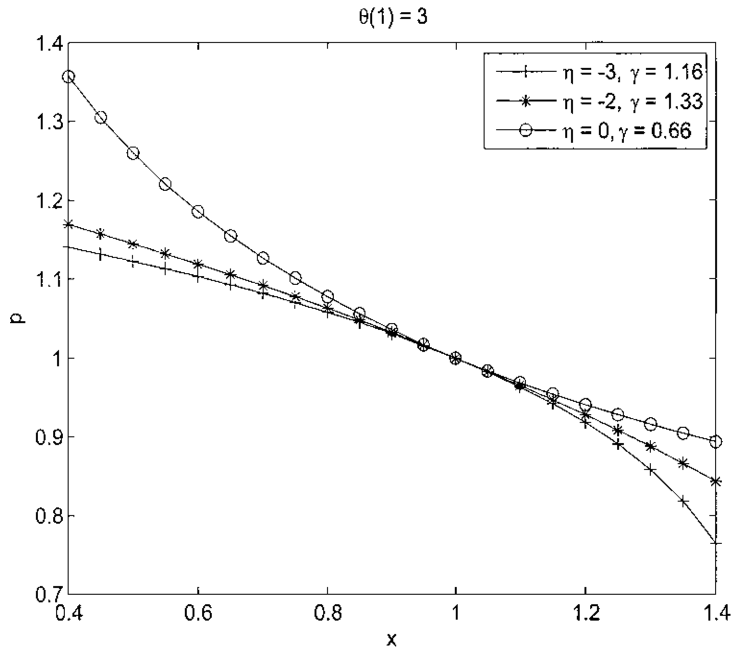

Fig. 10.3 Demand functions for various parametrizations; $\overline{\theta}(x) = 3$ at $x = 1$

The behavior of the various components of the "strategic complementarity" term of the slope, and the slope itself,[24] computed with the parametrization of Levin, Lopez-Salido, and Yun (2006)[25] is shown in figure 10.4. These functions are all evaluated at the market share $x = \psi^{-1}(1/N)$, thus they are a function of the number of goods traded in steady-state N, which is reported on the horizontal axis. The graphs on the top row show the steady-state market share x and the demand elasticity $\overline{\theta}$, those on the second row show the markup $\overline{\mu}$ and the markup elasticity $\overline{\varepsilon}_\mu$, and the last row reports the elasticity of the marginal cost to output $\overline{s}_y$ and the Phillips curve slope ζ.

In each graph the curves with crosses depict the case of a more concave demand ($\eta = -3$ and $\gamma = 1.07$) while the curves with stars correspond to a less concave demand function ($\eta = -2$ and $\gamma = 1.14$). Note how the decline in the desired markup is consistent with the evidence that an increase in trade is making the economy more competitive, as documented, for example, by Chen, Imbs, and Scott (2006) for European countries.

The behavior of the strategic complementarity term depends on the rela-

24. The slope is computed for a given nominal rigidity term. This term is defined as $((1 - \alpha)(1 - \alpha\beta))/\alpha$ and does not depend on N. By calibrating $\beta = .99$ and $\alpha = .7$, the assumed nominal rigidity corresponds to an average interval of nine to ten months between price changes.

25. That is, the combinations of the parameters η and γ are such that the demand elasticity in a steady state with unit market share is equal to 7.

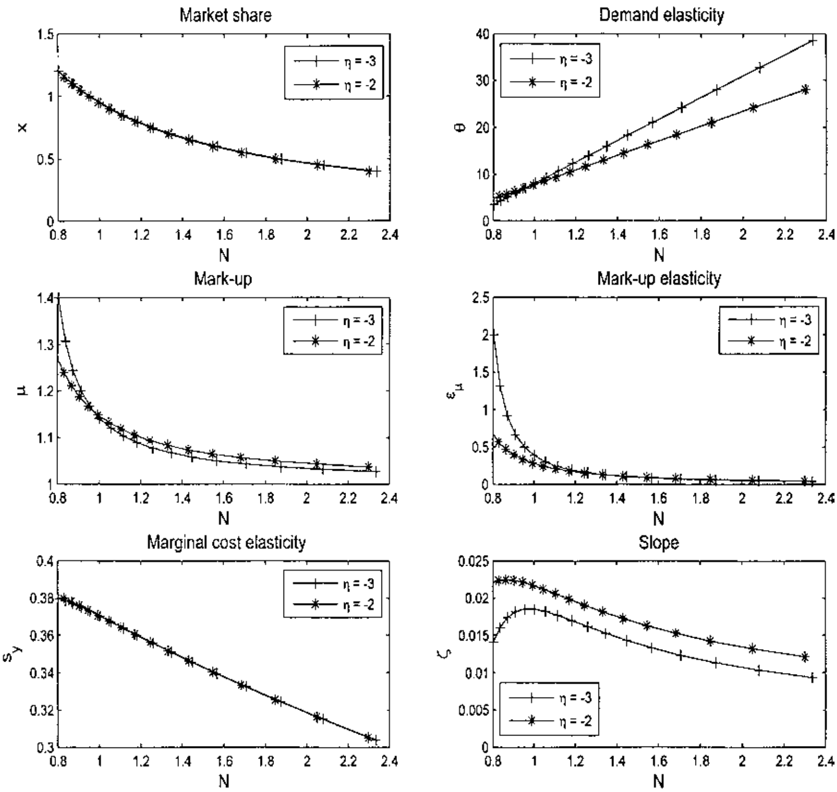

Fig. 10.4 Parametrizations: $\eta = -2$, $\gamma = 1.14$, and $\eta = -3$, $\gamma = 1.07$

tive response of the two terms on the denominator of expression (36), $\overline{\theta}(N)$ and $(\overline{\varepsilon}_\mu(N) + \overline{s}_y(N))$, to changes in the number of traded goods N. For both parametrizations reported in the figure, the demand elasticity $\overline{\theta}$ (graph on the top right corner) increases almost linearly in N; the elasticity $\overline{s}_y$ (graph on the bottom left of the figure) and the markup elasticity $\overline{\varepsilon}_\mu$ decline with N. The markup elasticity, in particular, which is a convex function of N, declines very rapidly as N starts to increase, more so when the demand function is more concave—the case depicted by the crossed curves in the figure. This sharp decline in $\overline{\varepsilon}_\mu$ causes the decline in the term $(\overline{\varepsilon}_\mu + \overline{s}_y)$ to dominate the increase in the elasticity $\overline{\theta}$, thus generating a moderate increase in the slope of the Phillips curve for these values. In the case of a less concave function, as the starred lines show, the changes in the two terms $\overline{\theta}$ and $(\overline{\varepsilon}_\mu + \overline{s}_y)$ offset one another at low values of N so that the slope is essentially unchanged, and then it declines monotonically when N increases further. For large enough values of traded goods, however, the slope declines regardless of the concavity of the demand function.

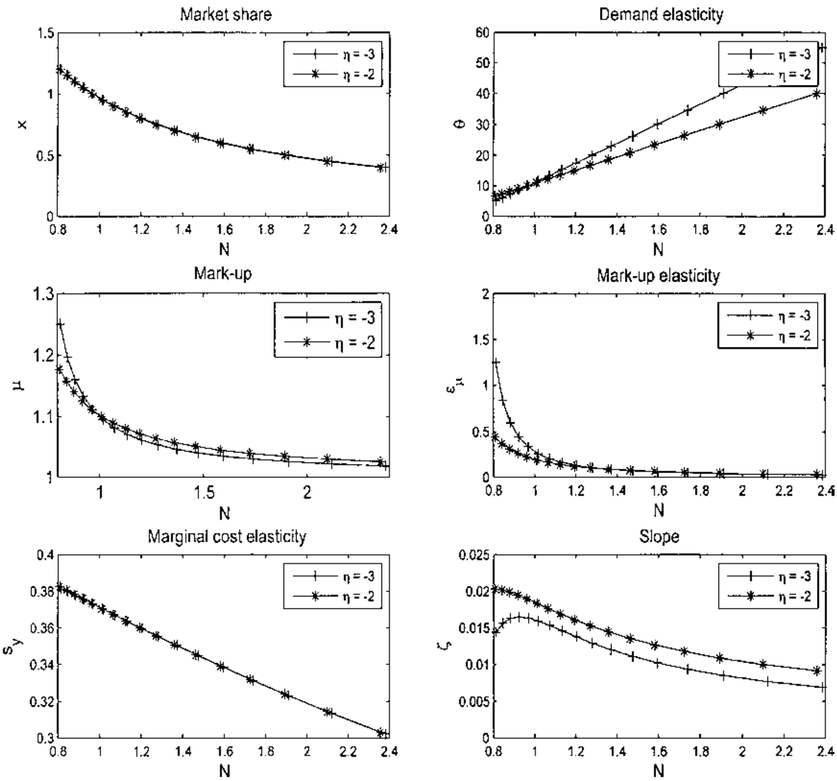

Fig. 10.5 Parametrizations: $\eta = -2$, $\gamma = 1.10$, and $\eta = -3$, $\gamma = 1.05$

To evaluate the sensitivity of the outcome depicted in figure 10.4 to different calibrations of the parameters of the aggregator function, the next two figures plot the behavior of the same variables for the two alternative parametrizations found in the literature.

Figure 10.5 is obtained by choosing parameters as in Dotsey and King (2005). Both combinations of the parameters η and γ indicated in the figure deliver a steady-state demand elasticity $\overline{\theta}(1) = 10$, which is higher than the case presented in figure 10.4. As the figure shows, this case is relatively similar to the previous one, except that the function $\overline{\varepsilon}_{\mu}$ has a less steep path. As a consequence, the extent of the increase in the slope when N increases near the low initial level is reduced.

One observes, instead, larger differences for the case where the aggregator function is parametrized in line with the empirical estimates of demand elasticity from microdata (e.g., Broda and Weinstein 2006). In this case the demand elasticity in the steady state with unit market share is set to a smaller value than in the baseline case: $\overline{\theta}(1) = 3$. This case is reported in figure 10.6.

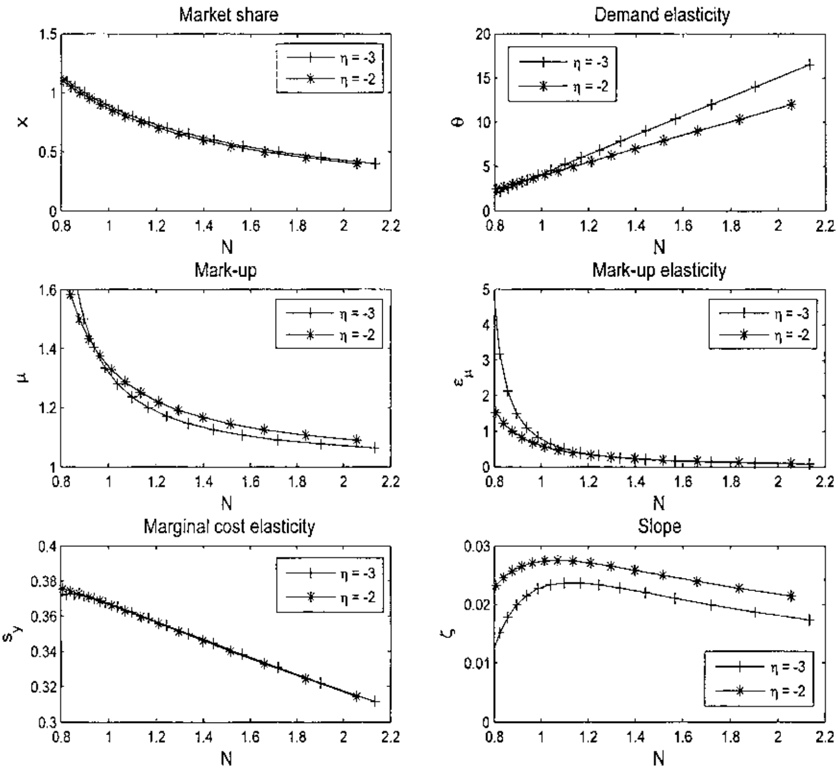

Fig. 10.6 Parametrizations: $\eta = -2, \gamma = 1.33$, and $\eta = -3, \gamma = 1.16$

The assumption of a smaller elasticity in the initial steady state implies less curvature of the demand function when the relative price increases (see previous figure 10.3). As a consequence, the elasticity of demand increases at a slower pace when the number of traded goods increases, while the desired markup, which starts from more elevated values because of a lower initial elasticity, declines rapidly. The markup elasticity, very high in the initial steady state, declines sharply, making the term $\bar{\varepsilon}_\mu$ dominate the behavior of the slope. As the graph on the lower right corner shows, in this case the slope of the Phillips curve indeed increases for a larger range of values of N for both parametrizations in the figure, and more markedly so the more concave is the demand function. Furthermore, although as N grows the slope eventually declines, it remains always above its initial value for the range of increases in traded goods considered in the figure.

Overall, the message of those graphs is that an increase in competition, in this model, does not necessarily have the effect of reducing the slope of the Phillips curve. While it is true that competition increases the elasticity of demand faced by the producers, it also determines a decline in the desired markup pricing of the firms, and it is the way in which these two effects play out that ultimately determines the effect of more competition on the Phillips curve trade-off.

10.6.1 Measuring the Trade Increase

The previous figures illustrate how moving from a steady state with low N to a steady state with high N can affect the slope of the new-Keynesian Phillips curve. However, they also show that the magnitude of the change in the slope is sensitive to the parametrization of the demand curve. And within each parametrization, it matters how big the change is in the number of traded goods going from one steady state to another, because of the non-monotonicity of the slope function ζ. Hence, in order to make a quantitative assessment of the impact of the increase in market competition on the new-Keynesian Phillips curve trade-off, one would need to measure the size of the increase in trade associated with the globalization of the 1990s in a way appropriate to represent the variable N of the model.

The U.S. goods imports increased significantly in the 1960 to 2006 period. Figure 10.7 shows that the share of goods imports on GDP went from a little more than 4 percent in 1960 to about 22 percent by the end of 2006, with an increase from about 12 to 22 percent since 1989. For this latest period, however, the increase in import share, excluding oil products, is more modest, going from about 8 to 12 percent.

The model, however, associates the increase in competition with an increase in the number of goods traded in the economy. For this purpose a more appropriate measure can be provided by the change in the number of varieties, as reported in the study by Broda and Weinstein (2006), which addresses the issue of the effect of globalization on trade.

Broda and Weinstein study the period 1972 to 2001, which they divide in two subperiods, 1972 to 1988 and 1990 to 2001. For each of them they report the number of varieties traded.[26] They register an increase in the total varieties of goods available to consumers of about 42 percent from 1990 to 2001: the number of varieties went from approximately 182,000 to about 259,000 (table I of the paper). They observe, though, that a large number of varieties have a very small market share: to correct for a possible bias, they also provide a measure of value-weighted varieties. Under this measure, the increase in varieties is much smaller, of the order of 5 percent.[27] In the following calculations I take these two numbers as rough measures of the increase in the number of goods N, and evaluate the effect of increases of this magnitude on the slope of the Phillips curve.

26. They define a variety as "import of a particular good from a particular country" (Broda and Weinstein 2006, 550) and use two different sources for each subperiod (data on 1989 are not included because of the unification of Germany in that year, which makes the data not comparable with those of the following years).

27. This measurement is obtained from the reported λ ratio in table VII of Broda and Weinstein (2006). The gross increase in varieties is computed as the inverse of the (median) λ ratio reported for the corrected count and for the one in table I.

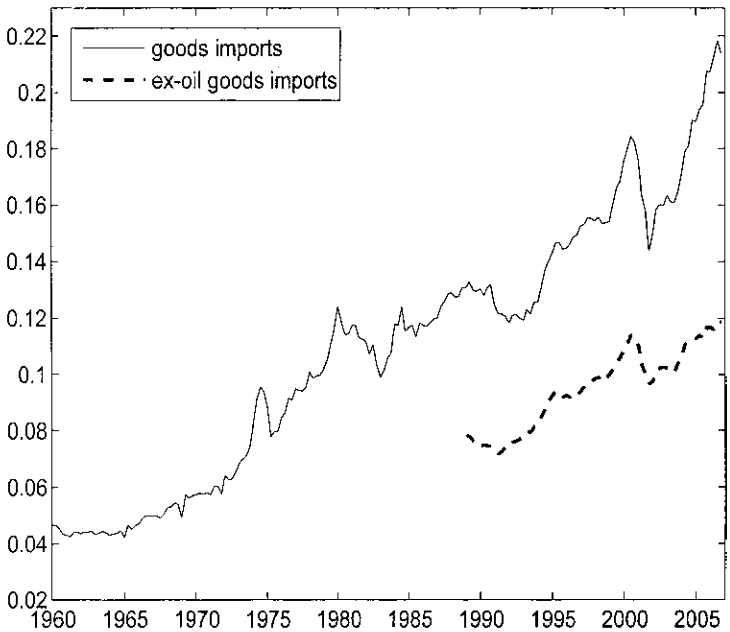

Fig. 10.7 Goods imports/GDP ratios, 1960–2006

Figure 10.8 reproduces four of the slope functions reported in previous graphs. The first row of the figure reproduces the two slopes obtained under the parametrizations of the aggregator function reported in figure 10.4. These parametrizations, to recall, assume a demand elasticity of 7 in a steady state with unit market shares, but differ about the curvature of the demand function around that point. The left graph corresponds to a more concave demand function ($\eta = -3$), the one on the right to a less concave demand ($\eta = -2$). Consider the left graph first: in the initial steady state the number of goods traded is approximately $N = 1/\psi(x) = 0.96$, while by construction the elasticity of demand at that point is $\overline{\theta}(1) = 7$. As discussed, the increase in the quantity of traded goods documented by Broda and Weinstein (2006) is of the order of 5 percent in terms of their value-weighted measure, but of about 42 percent when unweighted. The shaded area between the first two vertical lines (from left to right) indicates the effect of moving from the initial steady state to a new steady state, where the number of traded goods is 5 percent higher. The vertical line farther to the right indicates a new steady state where the number of traded goods is instead 42 percent higher than the initial value. As the graph shows, a 5 percent increase in N is too small a change to affect the size of the slope: the decline in the two functions $\overline{\varepsilon}_{\mu}$ and $\overline{s}_y$ is almost entirely offset by the increase in the elasticity $\overline{\theta}$, so that the slope is essentially unchanged, at a value of about 0.018. A 42 percent

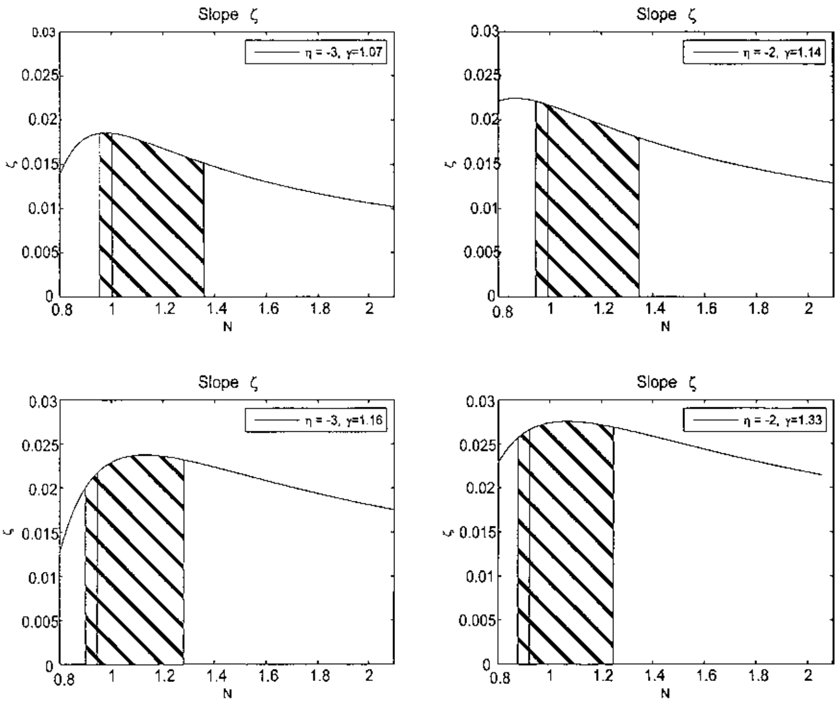

Fig. 10.8 Effect of *N* on the slope ζ

increase, on the other hand, generates an overall increase in the term $(\bar{\varepsilon}_{\mu} + \bar{s}_y)\,\bar{\theta}$, because the decline in the component $(\bar{\varepsilon}_{\mu} + \bar{s}_y)$ is more than offset by the increase in $\bar{\theta}$. Thus, the slope declines from about 0.018 to 0.015. In the case of a less concave demand function (graph on the upper right) even a small increase in the steady-state value of *N* has the effect of lowering the value of the slope. In this case, in fact, the increase in the elasticity dominates the "real rigidity" component of the slope, making ζ smaller for any value of *N* larger than its initial value.

The quantitative assessment that emerges from the second row of figure 10.8 is quite different. Here I report the Phillips curve slope as a function of the number of traded goods in the two parametrizations considered in figure 10.6. Relative to the previous case, these parametrizations assume that $\bar{\theta}(1) = 3$. As in the row above, the slope in the left graph is obtained under the assumption of a more concave demand function relative to the one on the right. In both cases, as discussed in the previous section, the slope tends to increase with *N* for a larger range of values. In the initial steady state the slope is about 0.019; in a steady state where the number of traded goods is only 5 percent higher, the slope rises to 0.021, and in a steady state where

N is almost twice as large the slope is 0.023. This result is robust to the assumption of a less concave demand function (graph on the lower right of the figure), although the value of the slope in this case is higher for all values of N.

Overall, according to the model presented, it would be difficult to argue that the increase in trade observed in the 1990s in the United States should have generated an increase in competition leading to a decline in the slope of the inflation/marginal cost relation. It is indeed quite possible that the increased competition has instead resulted in an increase in the slope. Moreover, this conclusion is obtained without allowing for any increase in the frequency of price adjustment in a more competitive environment, of the kind hypothesized by Rogoff (2003). Note, however, that since one is comparing two different steady states, the results depend very critically on the curvature of the demand function in the initial steady state, and on how far the new steady state is from the initial one.

10.7 Conclusion

In this chapter I discuss whether globalization, by generating an increase in market competition, has the potential of reducing the inflation output trade-off; namely, whether it is responsible for the flattening of the Phillips curve that many empirical analyses suggest occurred in the past twenty years or so.

I use the Calvo model of inflation dynamics to disentangle the components of this trade-off, and focus on the relationship between inflation and marginal costs. To analyze how this relationship, which I call the relevant "slope" of the curve, is affected by trade and market competition I depart from the model's traditional assumption of constant elasticity of demand, making this elasticity depend instead on the relative market share of the differentiated goods. When trade moves the economy from a steady state with low trade to one with higher trade, the elasticity of demand facing the firms increases, but the elasticity of the desired markup declines. The balance of these two forces is the key element determining how the degree of strategic complementarity, and with it the inflation-marginal costs component of the Phillips curve slope, vary.

I argue that it is not clear that the trade increase observed in the globalization period is strong enough to have generated a decline in this component of the slope. When marginal cost is related to output, there is a further effect of the trade increase on the overall slope, since in the model the elasticity of marginal cost to aggregate output comprises the elasticity $\bar{s}_y$, which is indeed a decreasing function of number of traded goods. This effect is, however, quantitatively small, as the figures show.

A proper analysis of all the effects of a more integrated economy on the inflation-output trade-off would require to move more clearly to an open economy setup, which would allow one to account for the price dynamics of goods produced abroad and consumed, as final or intermediate goods, in the domestic economy. As it has been shown (see, e.g., Razin and Yuen 2002) the open economy Phillips curve is flatter than the curve of a closed economy, even in the presence of a constant elasticity of marginal cost to output, because the overall slope is declining in a trade openness parameter. My analysis could be interpreted as an analysis of the effects of increase in competition—for a given degree of openness of the economy—when an increase in the actual trade takes place.

That said, it does not necessarily mean that globalization had no effect on inflation dynamics. Throughout my analysis I maintain that the nominal rigidity component of the slope is unchanged. This is not because the frequency of price changes is unaffected by a more global environment. It is simply because it is reasonable to assume that it is not the amount of trade per se that should induce a more frequent adjustment of prices. Price stickiness is instead typically motivated by reoptimization costs, which are essentially driven by the cost of gathering information.

Moreover, the claims that globalization affects the frequency of price adjustment go both ways. On one hand, Rogoff (2003) argues that globalization has led to greater price flexibility—in the model this translates in a lower α, hence in a steepening of the curve. On the other hand, if globalization has brought an overall lower level of inflation, as argued by many, then there is less incentive to revise prices often, because the cost of price misalignment is lower. Endogenizing the frequency of price adjustment is indeed an active area of research.

Appendix

This appendix explains how I compute the elasticity of marginal cost defined in expression (29) as a function of the number of traded goods N. This computation involves quantifying how aggregate output Y varies with N, and calibrating the fixed costs Φ. From expression (28), one derives the steady-state real marginal cost as

$$s = \frac{1}{1-a} w\,(xY + \Phi)^{a/(1-a)}, \tag{39}$$

where w denotes the steady-state real wage. Assuming a fairly standard preference specification: $u(C, h) = \log C - [1/(1+v)]h^{1+v}$, the desired real wage is $w_t = H_t^v C_t$. Aggregate hours H_t are

$$H_t = \int_0^N h_t(i)\, di = \int_0^N (y_t(i) + \Phi)^{1/(1-a)} di,$$

where I used the definition of hours in (27). Steady-state aggregate hours are then

$$H = N(xY + \Phi)^{1/(1-a)}.$$

Substituting H in the expression for the equilibrium real wage allows us to rewrite (39) as

$$s = \frac{1}{1-a} N^{\nu}(xY + \Phi)^{(\nu+a)/(1-a)} Y. \tag{40}$$

From expression (31) in the text the steady-state real marginal cost is $s = 1/(N\bar{\mu}x)$. Combining this expression with (40) I obtain that

$$xY + \Phi = \left(\frac{1-a}{\bar{\mu}xYN^{1+\nu}}\right)^{(1-a)/(\nu+a)}. \tag{41}$$

This expression defines a concave, increasing function $Y = Y(N)$. For a given calibration of the parameters a, ν, and Φ, each value of N determines a value of Y, which together with the value of x allows us to compute a value for the elasticity $\bar{s}_y$. I set the parameter ν to be equal to 2, which corresponds to a Frisch elasticity of labor supply of .5, the high end of the range typically found in micro studies, and I set $1 - a = .68$, to roughly match the average observed labor share for the United States. To calibrate the fixed cost of production Φ I first use the entry condition to establish a zero-profit upper bound to it, which I denote as Φ^u:

$$\Phi^u = \frac{1}{N^{1-a}}\left(1 - \frac{1-a}{\mu}\right).$$

Then I set Φ sufficiently close but strictly lower than Φ^u to allow entry of new firms with positive profits, and choose $\Phi = .2$. The results are not very sensitive to the range of values chosen for these parameters, since they have mostly a scale effect on $\bar{s}_y$, and hence on ζ, without affecting its curvature.

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Comment Tommaso Monacelli

Introduction

Does globalization affect inflation? This issue has attracted considerable interest recently, especially among monetary policymakers. Much of the attention has focused on the role of globalization in the form of increased trade integration. Yet if the link between globalization and inflation seems suggestive, it is not clear whether it pertains to the *level* as opposed to the *volatility* of inflation (or both). For instance, Rogoff (2006) argues that globalization strengthens the degree of competition and therefore dampens the inflationary bias temptation of the monetary authority, thereby leading to lower *average* inflation. Somewhat differently, Bernanke (2006) argues that the link between globalization and inflation may work via two complementary channels: a direct (*terms of trade*) effect due to lower import prices,

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