Globalization and inflation dynamics: a structural perspective*

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Abstract

The paper addresses the issue of how globalization may have impacted the slope of the Phillips curve. Starting from the Calvo model of staggered price setting, I modify some of its standard underlying assumptions to provide a channel for an increase in trade openness to affect the elasticity of inflation to marginal costs. After assessing qualitatively the nature of the impact of trade openness, I evaluate whether the increase in the varieties of goods traded since the dating of globalization, as documented in the empirical literature, might have had a sizable negative impact on the component of the slope of the new Keynesian Phillips curve that relates domestic inflation to real marginal costs.

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1. Introduction

The paper intends to explore how globalization might have impacted US inflation, using as framework for the analysis a structural model of inflation determination.

The policy debate about the macroeconomic effects of globalization has centered on two themes: that globalization has contributed to lower US inflation, and that it has affected the sensitivity of inflation to output fluctuations. In several speeches, policymakers have addressed the issue of whether more intense competition from abroad due to increased trade has changed the role of domestic factors in shaping the inflation process. Chairman Bernanke (2007), for example, has underlined how the dependence of factor markets from 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 US inflation.

I will not be discussing here all the reasons why market globalization might have affected US inflation; I will address only the particular issue of how globalization might have changed the dynamics of the inflation response to marginal costs.

In particular, I will make use the workhorse model of inflation dynamics of the new Keynesian literature to gain insights into how an increase in trade may affect the inflation response to marginal costs, hence enhancing or reducing the extent of the trade-off between inflation and output gap, the so called 'slope' of the Phillips curve.

2. Has the slope of the Phillips curve changed?

Concerns that the Phillips curve has become flatter in recent years echoed in most of the policymakers' remarks. The concern is that a flatter Phillips curve carries the implication that, for a given degree of inflation persistence, the cost of reducing inflation involves a higher 'sacrifice ratio' than otherwise, namely it requires a longer period of unemployment above the natural rate for every desired percentage point of reduction in inflation.

According to a recent BIS study by Borio and Filardo (2007) estimates of traditional Phillips curves show for many countries 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 the domestic output gap, going from the 1980-1992 period to the 1993-2005 period. For the United States, in particular, they report a decline in the estimated coefficient of lagged inflation from .92 to .82 across the two samples, and a decline in the elasticity to the output gap from .13 to .09. They use this result to motivate the investigation of the '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) find 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 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 '90s; it contests the interpretation that this is indeed due to the globalization hypothesis. Overall, the authors conclude in fact that the estimated effect of foreign output gaps is in general insignificant, that there is no evidence that the trend decline in the sensitivity of inflation to domestic output is due to globalization, nor they find increased sensitivity of inflation to import prices.

An 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 as evidence that the increase in trade has contributed to the decline in the Phillips curve slope. However, the study examines the group of advanced economies as a whole, and doesn't present results for the US alone. In the context of a similar, traditional, Phillips curve Ball (2006) allows interaction of the output coefficient with trade, and finds only a modest effect.

3. Channels through which globalization may affect inflation

The basic channel emphasized both in the policy debate and in these empirical studies as potential carrier of effects on the inflation dynamics is trade integration, which especially when accompanied by policy incentives, is argued to 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 pressures to innovate, which contribute 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's useful to decompose the relation between CPI inflation and domestic output, the one analyzed in the cited empirical studies, in three distinct parts. First, there is the relation between CPI inflation and domestic inflation. In an open economy, inflation is also affected by the price dynamics of good produced abroad that are consumed at home. Secondly, 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 relation, that concerns the way in which marginal cost variations determine inflation fluctuations, is the focus of most of the studies in the new Keynesian literature, that build on models of staggered price setting to derive implications for aggregate inflation. The strength of this relation depends on a number of factors. First, it depends upon the frequency of price revisions: the longer prices are kept fixed, the more nominal disturbances translate into real effects, rather than in aggregate inflation. This is the nominal rigidity channel. Second, there is the sensitivity of the desired firms' price to marginal costs versus other prices. If price setters take into account what other firms' prices are when they set their 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. Third, there is the sensitivity of marginal costs to the own 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 lower because the firm takes into account the decline in marginal cost due to the loss in demand when the price is increased. Finally the pricing decisions are affected by the sensitivity of the firm's own output to its relative price, namely to how elastic is the demand curve of the individual producer.

The last three channels are commonly referred to as 'strategic complementarity' or 'real rigidity' channels.[1] All are known to be important in assessing the slope of the new Keynesian Phillips curve with respect to marginal costs. They have been not only discussed theoretically, but also explored

[1] See Woodford (2003) ch. 3. The term 'real rigidity' was introduced, I believe, by Ball and Romer (). .

in empirical work with the purpose of reconciling estimated 'slopes' with reasonable degrees of nominal rigidity.[2]

My purpose in this paper is to investigate how these channels 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.

I borrow for that from the trade literature, where in a recent contribution Melitz and Ottaviano (2005) develop a model of trade with monopolististic competition and firm heterogeneity to study the effect of trade liberalization on productivity and mark-ups. 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 a macro general equilibrium model by Bilbiie et al (2006a and 2006b) to study endogenous entry as a propagation of business cycles, and efficiency properties of the model, always in a framework of flexible prices.

Here I study instead a model of staggered prices. My purpose is to analyze the implications that an elasticity of demand that depends on the number of goods traded carries for the dynamics of the inflation - marginal cost relationship.

My focus will be exclusively on the inflation - marginal cost relationship. I will not discuss the other two components of the CPI inflation - domestic output relationship: such a discussion would require that I consider a more complex open economy framework.

Nor I will discuss other effects of globalization on inflation of the kind 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,[3] rather than to the market mechanisms to which I am interested in here.

[2] See literature cited later.

[3] 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 monetay policy, hence the gain from inflating.

4. A structural framework

The Calvo model of staggered prices provides a useful framework to build the various theoretical channels of the inflation-marginal cost relationship. The baseline model is well known, so I will just summarize the features that I need for my argument.

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

$$c_t(i) = C_t \left(\frac{p_t(i)}{P_t} \right)^{-\theta} \tag{4.1}$$

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

$$C_t = \left[\int c_t(i)^{(\theta-1)/\theta} di \right]^{\theta/(\theta-1)} \tag{4.2}$$

and P_t is the corresponding aggregate price (the minimum cost to buy a unit of the aggregate good C_t : $P_t = \left[\int p_t(i)^{1-\theta} di \right]^{1/(1-\theta)}$. The model further assumes random intervals between price changes: in every period, only a fraction $(1-\alpha)$ 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 $\alpha \to 1$). 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

$$E_t \left\{ \Sigma_{j=0}^{\infty} Q_{t,t+j} \mathsf{P}_{t+j}(i) \right\}, \tag{4.3}$$

where profits $\mathsf{P}_t(i)$ are a function $\mathsf{P}\left(p_t(i), P_t, y_t(i), Y_t; \Gamma_t\right)$; $y_t(i)$ is firm's output, defined by (4.1), $Q_{t,t+j}$ 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

$$E_t \left\{ \Sigma_{j=0}^{\infty} Q_{t,t+j} \mathsf{P}_1\left(p_t^*, P_{t+j}, y_{t+j}(i), Y_{t+j}; \Gamma_{t+j}\right) \right\} = 0, \tag{4.4}$$

where the evolution of aggregate prices is

$$P_t = \left[(1-\alpha)\, p_t^{*1-\theta} + \alpha P_{t-1}^{1-\theta} \right]^{\frac{1}{1-\theta}}. \tag{4.5}$$

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

$$\widehat{\pi}_t = \zeta \widehat{s}_t + \beta E_t \widehat{\pi}_{t+1} + u_t \tag{4.6}$$

where β is the steady state value of the discount factor, and the slope is defined as

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}. \tag{4.7}$$

In this basic framework, it is only nominal rigidities that determine how marginal costs translate into inflation fluctuations. In order to consider the other potential channels discussed above we need some generalization of the model.

4.1. The slope of the price/marginal cost relation: some generalizations

Some of the generalizations I consider have been added to the baseline model with the purpose of reconciling empirical estimates of the slope with a degree of nominal rigidity in line with that documented in firms' surveys.[4] In most cases in fact the environment is modified to include one or many of the sources of strategic complementarities that I discussed above: for any given degree of nominal rigidity strategic complementarities make the slope lower or, alternatively, a given 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 the simple case in which labor is traded on an economy-wide labor market, but capital cannot be instantaneously reallocated across firms, firms' marginal costs depend not only on economy-wide factors, but also on the firm's own output.[5]. As discussed, such dependence makes the desired

[4] For example, Blinder et al. (1998).

[5] 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) discuss 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.

increase in price, for any increase in marginal cost, smaller. In this case the slope ζ becomes

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha}\frac{1}{1+\theta s_y}. \tag{4.8}$$

where the strategic complementarity term $\frac{1}{1+\theta s_y}$ depends upon the sensitivity of marginal cost to own output s_y, and the elasticity θ which measures the sensitivity of the own output of the firm to its relative price. Under the current assumptions s_y depends only the form of the production technology. For a Cobb-Douglas production function with output elasticity with respect to labor equal to $1-a$, for example, s_y is equal to $a/(1-a)$. In the more general case of firm-specific labor markets, the strategic complementarity terms assumes a similar form, except that the parameter s_y includes also the elasticity of the marginal disutility of work with respect to output increases (Woodford, 2003).

Another characteristic of the standard *NKPC* model is its derivation as a (log) linear approximation of the model equilibrium conditions (4.4) and (4.5) around a steady state characterized by zero inflation. It has been pointed out, however, that for the purpose of empirical analysis zero inflation may not be a good hypothesis. If we were to approximate the equilibrium conditions around a steady state with positive inflation, the slope would include somewhat modified discount factor and rigidity coefficient. As shown by Ascari (2004) in such a case the slope coefficient would be (building upon the previous hypotheses as well):

$$\zeta = \frac{\left(1-\alpha\beta\overline{\Pi}^{\theta(1+s_y)}\right)\left(1-\alpha\overline{\Pi}^{\theta-1}\right)}{\alpha\overline{\Pi}^{\theta-1}}\frac{1}{1+\theta s_y}, \tag{4.9}$$

where $\overline{\Pi}$ denotes the gross 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 addition to a more complicated slope, the NKPC has also a richer dynamics, because it includes additional forward-looking terms. It should be noted, however, that the effects of trend inflation can be eliminated, even when log-linearizing around a steady state with positive inflation, by assuming that prices not re-optimized are indexed (at least partly) to trend inflation. In this case the additional dynamics is eliminated and the slope is unaffected by the steady state inflation $\overline{\Pi}$. An interesting generalization of this case is obtained when steady state inflation is assumed to be time-varying. In this case a similar curve is obtained by log-linearizing the equilibrium conditions around a steady state with time-varying trend inflation: the inflation gap is in this case the deviation of inflation from a time-varying trend: $\widehat{\pi}_t = \ln(\Pi_t/\overline{\Pi}_t)$

and marginal cost is similarly defined as $\widehat{s}_t = \ln \widetilde{s}_t = \ln(s_t/\overline{s}_t)$, where $\overline{\Pi}_t$ and $\overline{s}_t$ indicate trend variables.[6]

Finally, one may consider the case in which firm's desired mark-up over its marginal cost depends upon the prices of other firms. Since the desired mark-up depends on the firm's elasticity of demand, this case requires departing from the constant elasticity of substitution assumption of the 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 mark-up and sufficient real rigidity to make a model of sticky prices plausible (i.e. without having to assume too large a percentage of firms with long periods of unadjusted prices). His objective was to generate more flexible demand function, particularly 'kinked' demand functions, where for the firm at its normal market share it is easier to loose customers when 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 the kind of strategic complementarities that amplify the effect of nominal disturbances reducing the size of the slope of the Phillips curve. These preferences are discussed in the context of models with price rigidities in Woodford (2003). 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. This form has been considered by Levin, Lopez-Salido and Yun (2006) to analyze the interaction of strategic complementarities 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 re-optimization in the Calvo model. Finally, in the context of an open economy model, Gust et al. (2006) have extended these preferences to the demand of home produced and imported goods, to show that with strategic complementarities lower trade costs reduce the pass-through of exchange rate movements to import prices.

To remove the constant demand elasticity assumption, the consumption aggregate of (4.2) is

[6] In most general equilibrium monetary models in the new Keynesian literature trend inflation is assumed time-varying but the dependence of the slope on trend inflation is eliminated by the appropriate indexation assumptions. See, among others, Ireland (2006) and Smets and Wouters (2003). A NKPC with time-varying trend inflation in the coefficients is estimated by Cogley-Sbordone (2005, 2006).

replaced by an aggregate C_t implicitly defined by

$$\int_{\Omega} \psi\left(\frac{c_t(i)}{C_t}\right) di = 1 \tag{4.10}$$

where $\psi(.)$ is an increasing, strictly concave function, and Ω is the set of all potential goods produced (a real line). The Dixit Stiglitz aggregator considered before, which corresponds to the case where $\psi(c_t(i)/C_t) = (c_t(i)/C_t)^{(\theta-1)/\theta}$ for some $\theta > 1$. In this case one can show[7] that the Calvo model implies a similar form of the inflation - marginal cost relationship, where the slope takes the form (considering for simplicity the case of zero steady state inflation)

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha} \frac{1}{1+\overline{\theta}(\overline{s}_y + \overline{\epsilon}_\mu)}. \tag{4.11}$$

Here $\overline{\theta}$ 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, which I denote by x; $\overline{\epsilon}_\mu$ is the steady state value of the function $\epsilon_\mu(x)$ that represents the elasticity of the mark-up function $\mu(x)$ which also depends on the firm's relative sales, and $\overline{s}_y$ 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 terms in the strategic complementarity term $\frac{1}{1+\overline{\theta}(\overline{s}_y+\overline{\epsilon}_\mu)}$ determines to what extent the slope of the inflation - marginal cost can differ from the one of the baseline case.

Expression (4.11) formalizes all the elements discussed in section 3 as those that affect the strength of the relationship between inflation and marginal costs. It shows that the slope depends upon a number of variables: (i) the frequency of price revisions, represented by the coefficient α : less frequent price revisions (a higher value of α) correspond to lower ζ; (ii) the sensitivity of the desired firm's price to marginal cost versus other prices, the term $\overline{\epsilon}_\mu$: higher sensitivity reduces the slope; (iii) the sensitivity of marginal cost to the own output of the firm, the term $\overline{s}_y$; and (iv) the sensitivity of the firm's own output to the relative price, $\overline{\theta}$. In addition, the slope is possibly affected by the level of steady state inflation, which may interact with the demand elasticity, as in (4.9).[8]

The Calvo model enriched with the discussed modifications is now a suitable framework for discussing the effects of globalization: the task is to relate the factors that drive the value of

[7] See the later derivation for the specific parametrization considered.

[8] In this formula α is independent of $\overline{\Pi}$, hence the nominal rigidiy term is higher the lower is trend inflation. This effect can be partially offset by postulating a function $\alpha = \alpha\left(\overline{\Pi}\right)$, with $\alpha'\left(\overline{\Pi}\right) < 0$, in the assumption that at high levels of inflation prices are adjusted more often. I will consider later the effects of endogeneizing the frequency of price adjustments.

the slope to the increase in trade openness, that is one of the characteristics of a more global environment. This is what I consider next.

5. Kimball preferences with a variable number of goods

Here 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 in steady state, I make the elasticity of demand function of the number of traded goods. This implies that the degree of strategic complementarity varies with the number of traded goods as 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 (4.10), where $\psi(.)$ is an increasing, strictly concave function, and 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[9]

$$\int_0^N \psi\left(\frac{c_t(i)}{C_t}\right) di = 1. \tag{5.1}$$

We'll see below that with these assumptions the aggregator function implies that the elasticity of demand, defined as $\theta(x) = -\frac{\psi'(x)}{x\psi''(x)}$, and therefore the desired mark-up pricing over costs, depend upon the relative quantity 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.

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

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

The first order condition for this problem are

$$p_t(i) = \frac{1}{\Lambda_t C_t} \psi'\left(\frac{c_t(i)}{C_t}\right) \tag{5.2}$$

for each $i \in [0, N]$. The solution to this problem gives the demand for each good i as

$$c_t(i) = C_t \psi'^{-1}\left(p_t(i)\, \Lambda_t C_t\right), \tag{5.3}$$

[9] Note that this assumption doesn't affect the preferences: $c_t(i)$ is specified for all $i \in \Omega$ regardless of the value of N, and the utility function does not involve N. This contrast with Benassy's (1996) generalization of the Dixit-Stiglitz preferences, that depend on the value N.

where Λ_t is implicitly defined by the requirement that

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

This requirement defines a price index $\widetilde{P}_t \equiv \frac{1}{\Lambda_t C_t}$ for any set of prices $\{p_t\left(i\right)\}$, which is independent of C_t. We can then write the demand curve for good i as

$$y_t\left(i\right) = Y_t \psi'^{-1}\left(\frac{p_t\left(i\right)}{\widetilde{P}_t}\right). \tag{5.4}$$

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

$$P_t = \frac{1}{C_t}\int_0^N p_t\left(i\right) c_t\left(i\right) di = \int_0^N p_t\left(i\right) \psi'^{-1}\left(\frac{p_t\left(i\right)}{\widetilde{P}_t}\right) di \tag{5.5}$$

where the second equality follows from (5.4). Both P_t and $\widetilde{P}_t$, however, are homogeneous of degree one functions in $\{p_t\left(i\right)\}$.

5.1. Steady state with symmetric prices

We are interested in the properties of the demand curve in a steady state with symmetric prices $p_t\left(i\right) = p_t$ for all i. In this case it follows from (5.1) that the relative demand $c_t\left(i\right)/C_t$ is equal to

$$c_t\left(i\right)/C_t = \psi^{-1}\left(\frac{1}{N}\right) \tag{5.6}$$

for all i, and from (5.2):

$$\widetilde{P}_t = \frac{p_t}{\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)}, \tag{5.7}$$

while, from (5.5)

$$P_t = p_t\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]. \tag{5.8}$$

We define the elasticity of demand in such a steady state as $\overline{\theta}$, which is

$$\overline{\theta} = -\frac{\psi'\left(x\right)}{x\psi''\left(x\right)} \tag{5.9}$$

where $x = \psi^{-1}\left(\frac{1}{N}\right)$. While under the Dixit-Stiglitz assumption of constant elasticity of demand, $\theta\left(x\right) = \theta$ for all x, here the elasticity depends upon the relative market share of the good and its value in steady state, $\overline{\theta}$, is a function of the number of goods traded in steady state, N. I am

interested in seeing *how* this steady state elasticity $\overline{\theta}$ varies with N. The extent of this variation depends on how the elasticity function $\theta(x)$ varies with x.[10]

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, then, since $\psi^{-1}\left(\frac{1}{N}\right)$ is decreasing in N, it follows that $\overline{\theta}$ is *increasing* in N. This is in line with the general intuition that more goods are traded in a market, more likely is the demand to decrease more in response to a small increase in prices.

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

The elasticity of the mark-up function is defined as

$$\epsilon_{\mu}(x) = \frac{\partial \log \mu(x)}{\partial \log x} = \frac{x\mu'(x)}{\mu(x)} \tag{5.10}$$

which, evaluated at the steady state value $x = \psi^{-1}\left(\frac{1}{N}\right)$ is denoted as[11]

$$\overline{\epsilon}_{\mu} = \frac{x\mu'(x)}{\mu(x)} \quad \text{for} \quad x = \psi^{-1}\left(\frac{1}{N}\right). \tag{5.11}$$

The elasticity $\overline{\epsilon}_{\mu}$ determines how much $\overline{\mu}$ varies for a small variation in N.[12] Since

$$\frac{\partial \log \mu}{\partial \log N} = \frac{\partial \log \mu}{\partial \log x} \cdot \frac{\partial \log x}{\partial \log N} = \overline{\epsilon}_{\mu} \cdot \frac{\partial \log x}{\partial \log N}$$

and, since $\frac{1}{N} = \psi(x)$,

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

we have that

$$\frac{\partial \log \mu}{\partial \log N} = \frac{-\overline{\epsilon}_{\mu}}{N\psi^{-1}\left(\frac{1}{N}\right)\psi'\left(\psi^{-1}\left(\frac{1}{N}\right)\right)}.$$

[10] The function $\theta(.)$ could also be expressed as a function of the relative price, rather than the market share, as in Gust et al. (2006).

[11] Note that this elasticity could alternatevely defined as $\epsilon_{\mu}(x) = -\epsilon_{\theta}(x)/[\theta(x) - 1]$, where $\epsilon_{\theta}(x) = \frac{\partial \log \theta(x)}{\partial \log x}$.

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

The elasticity of μ with respect to N has therefore the opposite sign of the elasticity $\overline{\epsilon}_{\mu}$. In turn we can determine how $\overline{\epsilon}_{\mu}$ must vary with N by considering how $\epsilon_{\mu}(x)$ varies with x. Since we can argue that $\log \mu$ is a convex function of $\log x$,[13] it follows from definition (5.10) that $\epsilon_{\mu}(x)$ is an increasing function of x : we can then conclude that $\overline{\epsilon}_{\mu}$ is a *decreasing* function of N .

We have thus established that the steady state elasticity of demand $\overline{\theta}$ and the elasticity of the desired mark-up evaluated in steady state $\overline{\epsilon}_{\mu}$ are respectively *increasing* and *decreasing* N. The role of N in the price/marginal cost relationship is examined next.

5.2. The price setting problem

The firms pricing problem in this set up generalizes the one considered in section 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:

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

where $\mathsf{C}(.)$ is the firm cost function; generalizing (4.4), the FOC for this problem are

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

where $x\left(\frac{p_t(i)}{\widetilde{P}_t}\right) \equiv \psi'^{-1}\left(\frac{p_t(i)}{\widetilde{P}_t}\right)$. The functions $\theta(x)$ and $\mu(x)$ are the functions defined above, 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. Note that the real marginal cost is defined as the ratio $MC_t(i)/P_t$, not the ratio $MC_t(i)/\widetilde{P}_t$.

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

$$E_t \sum_{j=0}^{\infty} (\alpha\beta)^j \left[\begin{array}{c} \left(\widehat{p}_t^* - \Sigma_{k=1}^j \pi_{t+k} \right) + \overline{\epsilon}_{\mu} \overline{\theta} \left(\widehat{p}_t^* - \Sigma_{k=1}^j \widetilde{\pi}_{t+k} + \log\left(\frac{P_t}{\widetilde{P}_t}\right) - K \right) + \\ \overline{s}_y \overline{\theta} \left(\widehat{p}_t^* - \Sigma_{k=1}^j \widetilde{\pi}_{t+k} + \log\left(\frac{P_t}{\widetilde{P}_t}\right) - K \right) - \widehat{s}_{t+j} \end{array} \right] = 0 \qquad (5.12)$$

[13] 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 $\log \mu$ to be a concave function of $\log x$, because this would require $\log \mu$ to be negative for positive, and small enough x. But this can't happen, no matter how large $\theta(x)$ gets for small x. If $\log \mu$ must be convex at least for small values of x, it is convenient to assume that it is a globally convex function of $\log x$.

where $\widehat{p}_t^* = \log\left(\frac{p_t^*}{P_t}\right) - \log\left(\frac{p}{P}\right)|_{ss}$; $\pi_t \equiv \Delta \log P_t$, $\widetilde{\pi}_t \equiv \Delta \log \widetilde{P}_t$; $K \equiv \log\left(\frac{P}{\widetilde{P}}\right)|_{ss}$; $\overline{s}_y = \frac{\partial \log s}{\partial y_t(i)}|_{ss}$, and $\widehat{s}_t = \log s\left(Y_t;\Gamma_t\right) - \log s\left(Y;\Gamma\right)|_{ss}$. The steady state values follow from previous calculations. From (5.8)

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

from (5.8) and (5.7)

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

and since $\log s_t \equiv \log\left(\frac{MC}{p}\frac{p}{P}\right)$ it follows that it is:

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

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

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

which, to a first order approximation, gives

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

For P_t, as defined in (5.5), we have

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

which, to a first order approximation, implies

$$\log P_t = \frac{1}{N}\int_0^N \log p_t\left(i\right)di + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]. \tag{5.13}$$

Therefore, to a first order approximation,

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

and therefore

$$\widetilde{\pi}_t = \pi_t.$$

Under the assumption of Calvo staggered prices, we can also write the expression for the general price level (5.13) as

$$\begin{aligned}
\log P_t &= \frac{1}{N}\left\{\alpha\int_0^N \log p_{t-1}\left(i\right)di + \left(1-\alpha\right)\log p_t^*\right\} + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right] \\
&= \alpha\log P_{t-1} + \left(1-\alpha\right)\left(\log p_t^* + \log\left[N\psi^{-1}\left(\frac{1}{N}\right)\right]\right) \\
&= \alpha\log P_{t-1} + \left(1-\alpha\right)\left(\widehat{p}_t^* + \log P_t\right)
\end{aligned}$$

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

$$\alpha \log P_t = \alpha \log P_{t-1} + (1-\alpha)\,\widehat{p}_t^*. \tag{5.14}$$

5.3. The slope of the NKPC

The log-linearized equilibrium conditions (5.12) and (5.14) can now be expressed, respectively, as

$$E_t \sum_{j=0}^{\infty} (\alpha\beta)^j \left[\left(1 + (\overline{\epsilon}_\mu + \overline{s}_y) \left(\widehat{p}_t^* - \sum\nolimits_{k=1}^{j} \pi_{t+k} \right) - \widehat{s}_{t+j} \right) \right] = 0 \tag{5.15}$$

and

$$\pi_t = \frac{1-\alpha}{\alpha} \widehat{p}_t^* \tag{5.16}$$

With typical transformations, (5.15) and (5.16) imply again an expression for inflation of the form

$$\pi_t = \zeta \widehat{s}_t + \beta E_t \pi_{t+1} + u_t$$

where now the slope is defined as

$$\zeta = \frac{(1-\alpha\beta)(1-\alpha)}{\alpha} \frac{1}{1 + (\overline{\epsilon}_\mu + \overline{s}_y)\,\overline{\theta}} \tag{5.17}$$

and through $\overline{\epsilon}_\mu$, $\overline{s}_y$ and $\overline{\theta}$ the slope is now dependent on the number of goods N traded in steady state. As we saw $\overline{\epsilon}_\mu$ is decreasing in N, while $\overline{\theta}$ is increasing in N so the net effect of the term in their product is uncertain. How the term $\overline{s}_y \overline{\theta}$ varies with N depends also on the interaction of the two terms. I haven't discussed how $\overline{s}_y$ varies with N. This elasticity, as discussed earlier, depends on which assumptions one makes about the form of the production function and on whether it is assumed that the factors of production are traded on economy-wide or specific factor markets. With homogeneous factor markets, all factors are istantaneously reallocated and this elasticity is zero. With homogeneous labor markets, and firm-specific capital, this parameter depends only upon the form of the production function, while with specific labor markets it also depends upon the elasticity of the marginal disutility of work with respect to output increases. The dependence of the marginal cost function on aggregate output makes the elasticity $\overline{s}_y$ in these general cases a function of N. In the parametrization below, I will consider the particular case of a constant returns to scale production function and firm specific capital that, as discussed previously, makes $\overline{s}_y$ a constant term, and therefore the product $\overline{s}_y \overline{\theta}$ necessarily increasing in N.[14] Furthermore, an

[14] There are a number of cases that result in the marginal cost function to depend on aggregate output and therefore on the number of traded goods that I will investigate in a later draft.

additional effect of N comes through the term $\widehat{s}_t$. We can in fact rewrite (5.17) as

$$\pi_t = \zeta \left(\log s_t - \log \overline{s} \right) + \beta E_t \pi_{t+1} + u_t$$

where the steady state value of the marginal cost depends on N because both the steady state mark-up $\overline{\mu}$ and the steady state relative price p/P depend on N: $\log \overline{s}(N) = -\log \overline{\mu}(N) - \log \left[N \psi^{-1} \left(\frac{1}{N} \right) \right]$.

5.3.1. Quantitative effect of openness on the PC slope

For a quantitative evaluation of the effect of an increase in trade on the slope ζ, I adopt for the function $\psi(x)$ a specification along the lines of Dotsey and King (2005), choosing the following functional form

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

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

For this specific functional form we can then derive the demand function (5.3) as

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

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

We can also derive the following variables, that we defined for a steady state with symmetric prices, as function of N. The relative share x in (5.6) is

$$x \equiv \psi^{-1} \left(\frac{1}{N} \right) = \frac{1}{1+\eta} \left\{ \left(\frac{(1+\eta)\gamma}{N} + (-\eta)^{\gamma} \right)^{\frac{1}{\gamma}} + \eta \right\}, \tag{5.18}$$

the steady state elasticity (5.9) as function of N is

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

and the elasticity of mark-up in steady state (5.11) is the following function of N:

$$\overline{\epsilon}_{\mu} = \frac{\eta(\gamma - 1)(1+\eta)\psi^{-1}(1/N)}{\left(\eta - (1+\eta)\psi^{-1}(1/N) \right) \left(\eta - \gamma(1+\eta)\psi^{-1}(1/N) \right)}.$$

By calibrating the parameters η and γ, we can now evaluate the effect of an increase in N on the

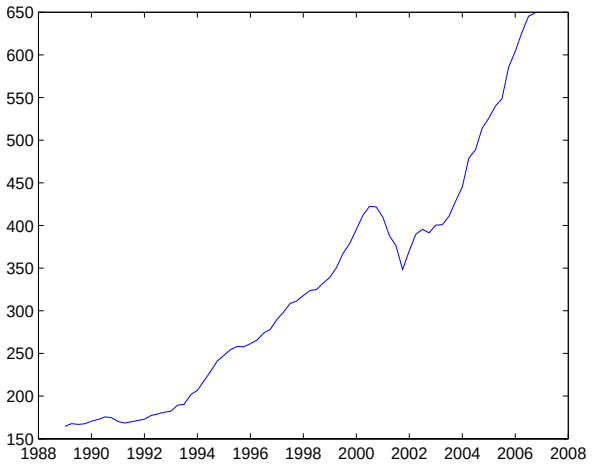


Figure 5.1: Good imports (ex-oil) 1989:Q1 - 2006:Q4

slope of the inflation - marginal cost function.

Suppose we want to analyze the effects of globalization, defined as the increase in trade that took place in the '90s. Figure 1 shows the increase since 1989 of the value of goods imports (ex oil); in terms of share of gdp, good imports grew from 3 to almost 5 percent. To have a measure of the number of goods, I refer to Broda and Weinstein (2006), who study the increase in the variety of traded goods for effect of globalization. They report for the period 1990-2001 an increase in the variety of goods available to consumers of about 42% : the varieties went approximately from 182,000 to 259,000. I will use these numbers to index the increase in the number of goods N under study.

Turning to the choice of parameter values, there is not too much guidance in the literature to what are the most plausible values for η and γ. One possibility is to choose a combination that guarantees a desired value for the mark-up (hence for the demand elasticity in the steady state with relative quantities $x = 1$). Dotsey and King (2005), for example, set $\gamma = 1.02$, and determine η so that $\overline{\theta} = 10$ (or 11% of mark up) at $x = 1$, which gives $\eta = -6$.[15] Levin et al. (2006) choose instead lower value for the demand elasticity at 1 in their baseline case, $\overline{\theta} = 7$, in order to have a markup of 16%, and set $\eta = -2$. Gust et al. (2006) choose η to match their model's implications for the volatility of output, and then select γ to give a 20% markup pricing in steady state ($\overline{\theta} = 6$). This

[15] It follows from (5.9) that for $x = 1$: $\overline{\theta} = \frac{-1}{(\gamma-1)(1+\eta)}$.

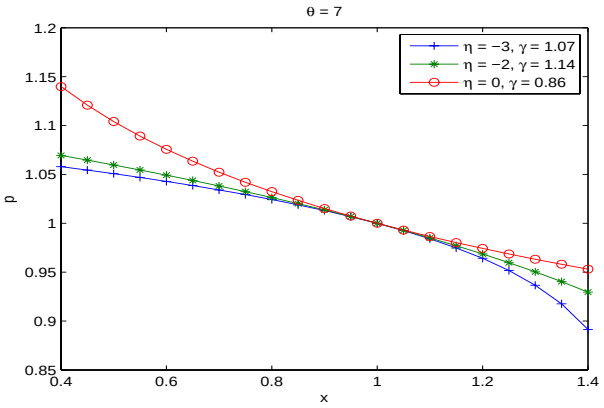


Figure 5.2: Demand functions for various η, $\overline{\theta} = 7$ at $x = 1$.

implies a value of $\gamma = 1.15$ and $\eta = -1.87$. Larger is η in absolute value (or closer γ approaches 1 from above) more concave is the demand function, as shown in figure 2. The case of $\eta = 0$ is the Dixit-Stiglitz case.

I will start by considering the implications of the Levin et al. parametrization, and then evaluate the case of a lower initial mark-up, as in Dotsey-King. Their assumed elasticity at the point of unit relative sales appears somewhat more in line with estimates with macro data.[16] With micro data, however, estimates of the elasticity of substitution depend on the level of aggregation. Broda and Weinstein (2006), for example, estimate elasticities for a larger number of goods at three different levels of aggregation, and found higher elasticities for more disaggregated sectors, showing that varieties are more close substitute when disaggregation grows. They report median elasticities for the period 1972-88 ranging from 2.5 to 3.7, depending on the aggregation level.[17] This suggests to investigate as well the effects of parametrizations based on the assumption of a lower elasticity in the initial steady state (I interpret the period 1972-1988 as a pre-globalization period). As for the choice of the particular combinations of the two parameters η and γ I chose the two values of η

[16] At the macro level, Cogley-Sbordone (2005) estimate a Calvo model with a Dixit-Stiglitz specification and time-varying inflation trend; we estimate the Dixit-Stiglitz elasticity using aggregate data on inflation, unit labor costs, output and interest rates, but do not find evidence that the elasticity differ across periods that we choose a priori as representing periods of different steady state inflation. We estimate relative constant elasticities, around 11, for all the periods.

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

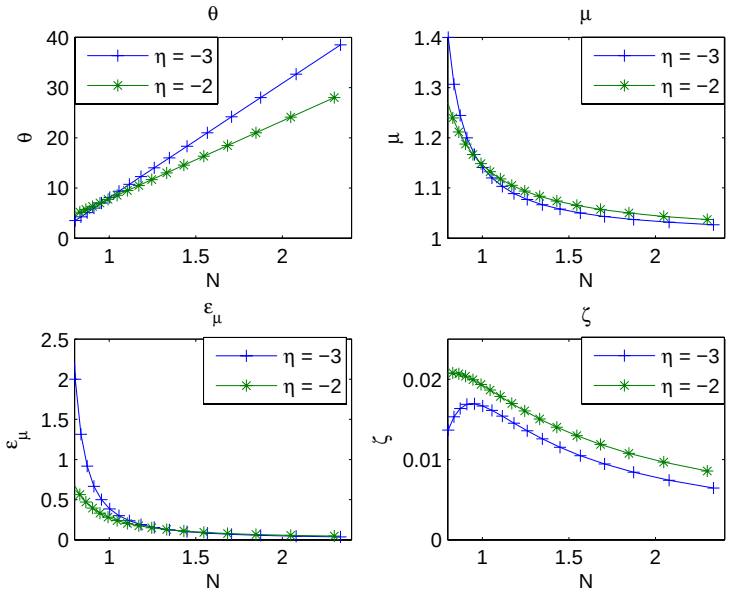


Figure 5.3: Parametrizations: $\eta = -2, \gamma = 1.14$, and $\eta = -3, \gamma = 1.07$

reported in the figure: smaller values would make the demand curve too kinked.

Figure 3 shows in the top two graphs the behavior of the steady state demand elasticity $\overline{\theta}$ and the mark up $\overline{\mu}$ as functions of the number of traded goods N (using $x = \psi^{-1}(1/N)$). The decline in the desired mark-up 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 two graphs on the bottom show the markup elasticity $\overline{\epsilon}_\mu$ and the slope ζ. The starred curves correspond to less concave demand functions ($\eta = -2$, and $\gamma = 1.14$); the curves with crosses correspond to more concave demands ($\eta = -3$, and $\gamma = 1.07$).

The slope depends upon the effect of the two products $\overline{\theta}\overline{\epsilon}_\mu$ and $\overline{s}_y\overline{\theta}$. The elasticity $\overline{\theta}$ is increasing in N, and $\overline{\epsilon}_\mu$ is decreasing in N. The behavior of the product $\overline{\theta}\overline{\epsilon}_\mu$ depends on which effect prevails. The second effect on the slope, through the product $\overline{s}_y\overline{\theta}$, depends on how fast $\overline{\theta}$ grows; I assume in fact here that the elasticity $\overline{s}_y$ is constant, calibrated to the value .467,[18] and therefore the product $\overline{s}_y\overline{\theta}$ is increasing in N. The net effect of these terms, for the chosen parametrization, is illustrated in the last quadrant: the overall effect on the slope is null, or a small increase, for low values of

[18] If we take this to be the case with an economy-wide labor market and firm-specific capital, the value of the elasticity s_y corresponds to an output elasticity to labor in the production function of .68.

N, depending on the curvature assumed for the demand function. For large enough values of N, though, the slope declines in both cases.

With the functions implied by the chosen parametrization, if we characterize the initial steady state as one where $x = 1$, then in this steady state the number of goods traded is $N = 1/\psi(x) = .96$, while by construction the elasticity of demand is $\overline{\theta} = 10$. Considering the case of $\eta = -2$ (the starred green lines) an increase in the quantity of traded goods of the size documented by Broda an Weinstein implies an increase of N to 1.36, and a corresponding reduction in the market share to $x = .693$. The elasticity of demand at this point is higher than the initial value, at about $\overline{\theta} = 13$. The mark-up elasticity $\overline{\epsilon}_\mu$, for this change in the value of N, goes from .3 to about .12, a large enough decline that compensates for the increase in $\overline{\theta}$: the product $\overline{\theta}\overline{\epsilon}_\mu$ declines from 2.3 to about 1.65. However, the component $\overline{s}_y\overline{\theta}$ increases enough to increase the overall term $(\overline{\epsilon}_\mu + \overline{s}_y)\overline{\theta}$, with the effect of making the 'real rigidity' component of the slope ζ, the term $\frac{1}{1+(\overline{\epsilon}_\mu+\overline{s}_y)\overline{\theta}}$, smaller and the slope decline from 0.019 to 0.015.

In the case of a more concave demand function, as seen from the blue crossed curves, although the effect of a lower product $\overline{\theta}\overline{\epsilon}_\mu$ prevails for low N, the considered increase in N still decreases the slope, from 0.017 to 0.013.

To evaluate how sensitive this outcome is to different specifications of the parameters of the aggregator function, the next two figures consider in turn the same results for two different parametrizations, one that constrains the parameters to deliver a lower mark-up in a steady state with unity relative shares (the Dotsey-King case), the other with a very high steady state mark-up (the case of Broda-Weinstein). The specific parameters are indicated in the figure.

Figure 4 plots again the elasticity $\overline{\theta}$, the mark-up, μ, the mark-up elasticity $\overline{\epsilon}_\mu$ and the slope ζ as functions of N for a combination of η and γ that delivers a demand elasticity $\overline{\theta} = 10$ at $x = 1$. This case is relatively similar to the previous one, except for the weaker effects of the term $\overline{\theta}\overline{\epsilon}_\mu$ on the slope. Placing the initial steady state at the same values of the previous case, the slope is now 0.017 at the initial level of N, and declines to .012 at the new trade level.

Larger differences can instead be observed for the case in figure 5, where the initial elasticity is set to a lower value of 3.

In this case the mark-up elasticity is much higher and its fast decline makes the decline in the term $\overline{\theta}\overline{\epsilon}_\mu$ dominate the behavior of the slope, which in this case increases more markedly at low values of N. For the particular increase in trade that I am considering, the effect on the slope is

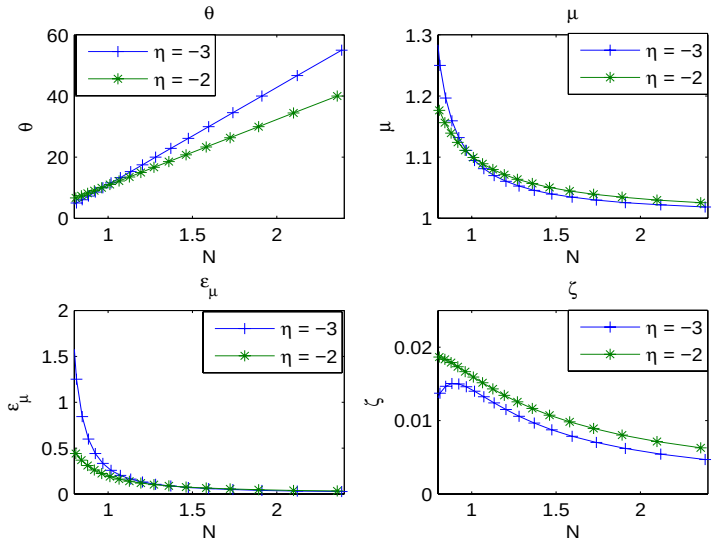


Figure 5.4: Parametrizations: $\eta = -2, \gamma = 1.10$, and $\eta = -3, \gamma = 1.05$

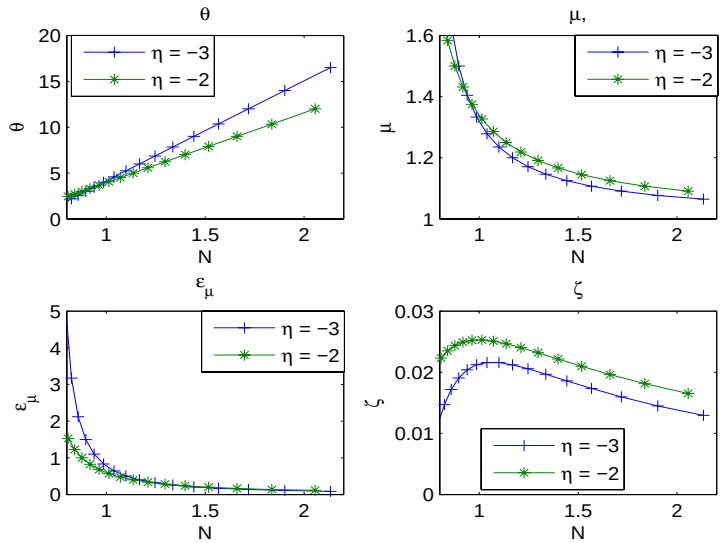


Figure 5.5: Parametrizations: $\eta = -2, \gamma = 1.33$, and $\eta = -3, \gamma = 1.16$

basically muted. For the less concave demand function the slope has an initial value of 0.0244, which is virtually unchanged with the increase in N, at 0.0237. In the case of the more concave demand function, the increase in trade actually increases the slope, although by a fairly small amount, from 0.019 to 0.02.

Overall, for the assumption made and the parametrization considered, a trade increase of the size considered does not generate necessarily a decline in the slope of the inflation/ marginal cost relation.

These are of course illustrative examples that do not make a strong case, and need further refining. I have focused, for example, more on the strategic complementarities arising from the shape of the demand function, and investigated little the role of those coming from firm-specific factor markets: I have for example considered only the case of a constant, although non zero, elasticity of marginal cost to own firm's output. More can be learned both from investigating alternative parameterizations of the aggregator function, and from evaluating the effect of alternative hypotheses built in the model, particularly with respect to the structure of the marginal cost function. [more on that]

And I have not yet investigated the potential effect of greater trade openness on the degree of price rigidity: this requires endogeneizing the frequency of price changes to allow variations in the 'nominal rigidity' component of the slope. [more on that]

Finally, I have considered a model approximated around a steady state with zero inflation, while it may be important to extend the analysis to evaluate the interplay of the factors considered with a positive inflation level in steady state.

6. Conclusions (to be written)

References

[1] Ball, L., 2006. Has Globalization Changed Inflation?, NBER wp 12687.

[2] Benassy, J-P., 1996. Taste for variety and optimum production patterns in monopolistic competition, *Economics Letters* 52: 41-47

[3] Bernanke, B. Globalization and Monetary Policy. Speech at the Fourth Economic Summit, Stanford Institute for Economic Policy Research, Stanford, March 2006.

[4] Bilbiie, F.O., Ghironi, F., Melitz, M.J., 2006a. Endogenous Entry, Product Variety and Business Cycle, unpublished.

[5] Bilbiie, F.O., Ghironi, F., Melitz, M.J., 2006b. Monopoly Power and Endogenous Variety in Dynamic Stochastic Gneral Equilibrium: Distorsions and Remedies, unpublished.

[6] Borio, C., Filardo A.,. 2007. Globalization and Inflation: New corss-country evidence on the global determinants of domestic inflation. BIS, unpublished.

[7] Broda,C., Weinstein, D., 2006. Globalization and the Gains from Variety, *Quarterly Journal of Economics,* 121(2)

[8] Chen, N., Imbs, J., Scott, A., 2006. Competition, Globalization and the Decline of Inflation, CEPR discussion paper n. 4695.

[9] Cogley, T., Sbordone A., 2006. Trend inflation and inflation persistence in the new Keynesian Phillips curve, Federal Reserve Bank of New York Staff Reports No. 270.

[10] Cogley, T., Sbordone A., 2005. A search for a structural Phillips curve. Federal Reserve Bank of New York Staff Reports No. 203.

[11] Eichenbaum, M., Fisher, J., 2007. Estimating the frequency of price re-optimization in Calvo-style models. *Journal of Monetary Economics.*

[12] Dotsey, M., King, R., 2005. Implications of state-dependent pricing for dynamic macroeconomic models. *Journal of Monetary Economics* 52 (1): 213-242.

[13] Gali, J., Monacelli, T., 2005. Monetary Policy and Exchange Rate Volatility in a Small Open Economy. *Review of Economic Studies*, 72: 707-734.

[14] Gust, C, Leduc S., Vigfusson, R.J., 2006. Trade Integration, Competition and the Decline in Exchange-Rate pass-Through, unpublished.

[15] Ihrig, J., Kamin, S.B., Lindner, D., Marquez, J. Some Simple Tests of the Globalization and Inflation Hypothesis. Board of Governors *International Finance Discussion Paper* n. 893, forthcoming

[16] International Monetary Fund. 2006. "How Has Globalization Affected Inflation?" World Economic Outlook, Chapter III, April.

[17] Ireland, P. 2005. Changes in the Federal Reserve's Inflation Target: Causes and Consequences, unpublished.

[18] Levin, A., Lopez-Slido, D., Yun, T., 2006. Strategic Complementarities and Optimal Monetary Policy, unpublished.

[19] Kimball, M. S., 1995. The Quantitative Analytics of the Basic Neomonetarist Model. *Journal of Money, Credit and Banking*, vol 27 (4): 1241-1277.

[20] Kohn, D.L. 2006. The Effects of Globalization on Inflation and Their Implications for Monetary Policy, Remarks at the Federal Reserve Bank of Boston's 51st Economic Conference, Chatam, Mass., June 16.

[21] Melitz, M., Ottaviano, G., 2005. Market Size, Trade and Productivity, unpublished.

[22] Rogoff, K., 2003. Globlization and Global Disinflation, Jackson Hole Symposium, August 28-30.

[23] Rogoff, K., 2006. Impact of Globalization on Monetary Policy, Jackson Hole Symposium, August 24-26.

[24] Sbordone, A., 2002. prices and unit labor costs: a new test of price stickiness, *Journal of Monetary Economics* 49 (2).

[25] Woodford, M. 2003. *Interest and Prices. Foundations of a Theory of Monetary Policy.* Princeton University Press.

[26] Yellen, J. Monetary Policy in a Global Environment. Speech at teh Conference 'The Euro and the Dollar in a Globalized Economy' University of California at Santa Cruz, May 2006.