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The International Transmission of Shocks in an Imperfectly Competitive International Business Cycle Model

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Abstract

This paper investigates the effects of introducing imperfect competition in an international business cycle model. We provide some international evidence on markups and analyze the implications of increasing returns to scale and monopolistic competition for the effects and the international transmission of technology and government spending shocks. We also consider exogenous markup fluctuations as a source of shocks and of transmission of business cycles. We show that imperfect competition improves the behaviour of a standard international business cycle model, although the behavior of foreign trade variables remains unexplained, and that it has important implications for the effects of government spending shocks. An imperfectly competitive model driven by government shocks can explain the international business cycle at least as well as a perfectly competitive model driven by technology and government shocks. The main effect of imperfect competition is the amplification of the effects of both technology and fiscal shocks, a fact which can be crucial when using these models for welfare analysis.

Key words: Imperfect Competition, International Business Cycles, Markups.

JEL Classification nos: C68, E32, F41,

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1 Introduction

Real Business Cycle theory has developed and expanded from the initial models of Kydland and Prescott (1982) and Long and Plosser (1983) in many directions, in order to solve the questions that these earlier models left unsolved (see, e.g., Benhabib et al. (1991) or Hansen (1985) for the labor market puzzles) or extend the analysis to previously unexplored areas, such as banking (Diaz Jimenez et al. (1994)) or money shocks (Cooley and Hansen (1989)).

As a way of making models more realistic, many authors have extended the basic framework to open economies, in an attemp to study the determinants of aggregate fluctuations in open economies and the transmission of idiosyncratic shocks across countries. For example, Mendoza (1991) and Lundviik (1991) have addressed the question of what generates aggregate fluctuations in a small open economy. Backus, Kehoe and Kydland (BKK) (1992) have considered a two country-one good model driven by technological shocks to investigate the international propagation of domestic cyclical fluctuations. Others have extended the basic one good framework to include multiple sources of shocks (e.g. fiscal policy (Baxter (1992)), household production shocks (Canova and Ubide (1995)), multiple sources of transmission (production and consumption interdependencies (Canova (1993)), nontradable consumption goods (Stockman and Tesar (1994)) and studied the properties of these models for trade issues (J-curve, see BKK (1993), policy questions (saving and investment correlations, see Baxter and Crucini (1993)) and insurance schemes (see e.g. Devereaux, Gregory and Smith (1992)). There have also been a few attempts to introduce money into these models, see e.g. Cardia(1991). Despite these efforts, there are still aspects of international data that these models fail to account for, e.g. the positive cross-country investment, hours and imports correlations (an exception is Canova and Ubide (1995)) and in particular the behaviour of foreign trade variables and the volatility of the terms of trade.

Contemporaneous to these developments, the field of international trade has experienced in the past decade a complete rethinking, with the emergence of the new view that much trade represents arbitrary specialization based on increasing returns. This fact has led to imperfect competition being a common feature of general equilibrium models of international trade (see. Helpman and Krugman (1985) for a survey). for many reasons. For example. protection in a small open economy may restrict market size and limit foreign competition. promoting many firms which operate at sizes too small in terms of economic efficiency and affecting the composition of imports and exports. Imperfect competition affects also the price and substitution mechanisms of the economy and therefore price discrimination in internationally segmented markets may lead to greater changes in relative prices than we see in models with perfect competition. However. it is a common feature of international business cycle models to assume perfect competition and constant returns to scale.

In this paper we merge both strands of the literature and examine the properties of an international business cycle model with imperfect competition. This modifies the price and substitution mechanisms of the model so that to alter the crucial dynamics governing investment. labor and the terms of trade. and therefore may lead to interesting results for issues such as the international transmission of shocks. the behaviour of the terms of trade or the analysis of coordinated government policies (as may be the case for the European Union).

This attempt is also supported empirically by the fact that micro-economic studies have provided evidence of substantial markups of price over marginal cost in many industries and countries (see. e.g.. Rotemberg and Woodford (1991) and references therein). Furthermore. as it was first stated by Hall(1988). one of the implicit assumptions of using Solow Residuals as a measure of productivity was the assumption of perfect competition. Hall demostrated that under perfect competition and constant returns to scale Solow Residuals have to be uncorrelated with exogenous variables. He tested this proposition for the U.S. and found the Solow Residual correlated with military spending. interpreting it as evidence in favour of imperfect competition. Ravn (1994) has found similar non-exogeneity results for Denmark. France and the U.K.. with the terms of trade being the most important variable explaining Solow Residuals. These findings clearly imply that in order to model an international economy driven by technology shocks we should take into account the existence of imperfect competition.

A second important point is that, as we have already mentioned, the large majority of papers in the International Business Cycle literature focuses on technology and/or government spending shocks as the driving forces of the economy. In this paper we put forward an additional source of shocks and transmission of business cycles: exogenous markup fluctuations. In our model, a markup shock is created by a change in the degree of substitutability of goods, that could come, for example, from market saturation and consumer pressure or changes in consumers tastes. Variable markups become a variable that shifts the labor demand curve. For example, consumer pressure could induce a reduction in markups that would increase output, hours and wages. Thus, we have three types of sources of shocks in our model: supply (technology), demand (government policy) and taste/market structure (markup).

Finally, it may be important to check whether the effects of both fiscal and technology shocks are robust to the presence of market power. Some authors have already examined this issue in closed economies. For example, Rotemberg and Woodford (1992) analyze a variety of models, including one with monopolistic competition, and their implications for output volatility. Hornstein (1993) uses a model with monopolistic competition and increasing returns to scale at the firm's level to analyze the effects of technological shocks on the volatility of U.S. output. Hairault and Portier (1993) analyze the effects of technology and monetary shocks in a model with monopolistic competition and price adjustment. Gali (1994) presents a model where endogenous variations in markups arise from composition effects. They all found imperfect competition to be an important feature of their models.

To the best of our knowledge, no one has yet considered the effects of imperfect competition and increasing returns to scale in an open economy framework. This paper presents some international evidence on markups and asks three basic questions: First, are the predictions of standard international business cycle models driven by technology and/or government spending shocks robust to the introduction of imperfect competition? Second, can a model driven solely by exogenous variations in markups account for the business cycle features of international data? Third, can a model driven by combinations of these sources of fluctuations improve the performance of existing models?

We present in Section 2 some new international empirical evidence on markups. In Section 3 we present a model economy that is an extension of the two country general equilibrium model of BKK (1993). It is a two-country. two-good general equilibrium model with government in which there are increasing returns to scale at the firm's level and monopolistic competition in goods markets. Aggregate technologies. government spending and markups can be subject to stochastic distubances. This set of disturbances makes our model considerably richer than standard models. and allows for several ways of transmission of business cycles across countries. First. international cycles may occur because of correlated technology innovations. Second. uncorrelated government spending shocks will generate trade in consumption and capital goods. and the possibility of coordinated government policies among groups of countries could drive the economies in certain directions. Third. uncorrelated shocks to markups create international cycles because of their effects on labor markets.

Section 4 presents the calibration of the model. In Section 5 we discuss the results obtained by simulating different versions of the model with different forcing processes. We analyze several models driven separatedly by technology and government shocks. In the case of government spending shocks we also consider the distinction between temporary and permanent shocks and the possibility of coordinated fiscal policies. For both sources of shocks we compare the cases of perfect competition. imperfect competition with constant markups and imperfect competition with variable markups. In order to better understand the contribution of imperfect competition to the dynamics of the models. we also study a model driven solely by markup shocks which also allows us to check whether markup fluctuations can drive the international business cycle. We show that the main results of the standard model driven by technology shocks are robust to the introduction of imperfect competition. and that this new feature can improve the performance of the model in several respects. However. the effects of fiscal policy are quantitatively different with respect to perfectly competitive enviroments. in particular for the effects on saving. investment. net exports and the terms of trade. Furthermore. if we account for imperfect competition. a fiscal shock is able to replicate the pattern of volatitilities and cross-country correlations that we see in the data. However. we have also uncovered a puzzle that a model driven by government shocks is not able to replicate, namely the positive correlation between government spending and the terms of trade that we find in the data. Section 6 concludes.

2 Some stylized facts

In this section provide some international evidence regarding the size and properties of markups across countries. Given that they are widely known and in order to save space, we report only a summary [1] in Table (6) and refer to Ubide (1995) for a detailed description of the stylized facts of International Business Cycles. In summary, these stylized facts show that consumption, employment, productivity and net exports are less volatile than output while investment, exports, imports and terms of trade are more volatile. All domestic variables are procyclical with respect to output with the exception of the ratio of net exports to output and the terms of trade, which are countercyclical. Basic saving, constructed as $S_t=Y_t-C_t-G_t$, and investment are positively correlated and the correlation is higher for larger countries. The behavior of net exports is less clear since it is negatively correlated with output in the U.S. but, in general, positively correlated in other countries. International comovements indicate that output is more correlated across countries than productivity. Hence, just as variation in productivity is not enough to explain domestic output fluctuations, it is also not enough to account for international output comovements. A second important regularity of international data is the low cross country consumption correlations, lower in general than the corresponding output correlations. Investment and employment also display positive comovements across countries and the same occurs for imports and exports.

The evidence on markups in the literature is contradictory and refers mainly to the U.S.. Using value added data, Hall(1988) reports values of markups above 2 for the U.S. whereas Domowitz, Hubbard and Petersen (1988) use a highly dissagregated panel data set and find values around 1.6. Recently, Norrbin (1994), introducing intermediate inputs in

[1] The column labeled "Data", which is taken from Ubide (1995) and corresponds to the main OECD countries for the period 1970:1-1993:4.

his data set, has found markups to be considerably smaller, around 1.1. The only non U.S. evidence we are aware of is Portier (1994), who finds a markup of 1.37 for France. Therefore, it seems worthwile to estimate markups consistently for an international data set.

Following Hall (1988) and Rotemberg and Woodford (1991), we use the macro value-added production function

$$y_t = AF(K_t, x_t H_t) - I_t x_t \Phi \qquad (1)$$

where K_t and H_t are the amount of capital and labor inputs respectively, I_t is the number of firms, Φ is and overhead or fixed cost, x_t is an exogenous labour augmenting Hicks neutral deterministic technological progress and A is a stationary technology shock.

After log-linearizing around the steady state,

$$\dot{y}_t = \frac{A}{y}\dot{a}_t + \frac{AKF_1}{y}\dot{k}_t + \frac{AxF_2 - Ix\Phi}{y}\dot{x}_t + \frac{AxHF_2}{y}\dot{h}_t + \frac{xI\Phi}{y}\dot{I}_t \qquad (2)$$

We are assuming that the economy has perfectly competitive factor markets but imperfectly competitive goods markets. This has the implication that firms have some market power, represented by the level of markup μ (the ratio of factor marginal remuneration over factor marginal productivity). The aggregate factor demands at the steady state are given by

$$\begin{aligned} AF_1 &= \mu^* r \\ AxF_2 &= \mu^* w \end{aligned} \qquad (3)$$

Expressing the payments to capital and labor in terms of factor shares (i.e. $sk = rk/y$),

$$\begin{aligned} AF_1 \tfrac{K}{Y} &= \mu^* sk \\ AxF_2 \tfrac{H}{Y} &= \mu^* sh \end{aligned} \qquad (4)$$

Since F is homogeneous of degree one, we have

$$1 = \frac{AF_1}{Y}K + \frac{AxF_2}{Y}H - \frac{Ix\Phi}{Y} \tag{5}$$

Assuming that all the technological progress is labor augmenting (so that $a_t=0$), using (2), (3), (4) and (5), we obtain the expression for true technological progress:

$$\dot{x}_t = \frac{\dot{y}_t - \mu^* sk\, \dot{k}_t - \mu^* sh\, \dot{h}_t - s_\phi\, \dot{I}_t}{1 - \mu^* sk} \tag{6}$$

Solving for μ in eq. (3) and log-linearizing

$$\dot{\mu}_t = \dot{x}_t - \dot{w}_t + \frac{\mu^* sk}{e}\left(\dot{k}_t - \dot{x}_t - \frac{\mu^* sh}{1 - \mu^* sk}\dot{h}_t\right) \tag{7}$$

Substituting $\dot{x}_t$ from (6) we obtain an expression for the markup series:

$$\dot{\mu}_t = \frac{e - \mu^* sk}{e - e\mu^* sk}\dot{y}_t + \frac{(1-e)\mu^* sk}{e - e\mu^* sk}\dot{k}_t - \frac{\mu^* sh}{1 - \mu^* sk}\dot{h}_t + \frac{s_\phi(e - \mu^* sk)}{e(1 - \mu^* sk)}\dot{I}_t - \dot{w}_t \tag{8}$$

Because of the lack of data for the rental price of capital and the number of firms at quarterly frequency and over a large sample, we will proxy the variations of markups by

$$\dot{\mu}_t = \frac{e - \mu^* sk}{e - e\mu^* sk}\dot{y}_t - \frac{\mu^* sh}{1 - \mu^* sk}\dot{h}_t + \dot{w}_t \tag{9}$$

However, as BKK(1992) pointed out, the cyclical variability of capital is small compared with that of output so that the omission of this variable from equation (9) is not relevant. We also assume that entry and exit of firms is not instantaneous, and therefore the cyclical properties of markups may be well represented by this proxy. In order to estimate these series we need values for the parameters e and μ^*.

e is the elasticity of substitution between factors in the production function. It is equal to 1 in the case of Cobb-Douglass production function. Therefore, we use the value $e = 1$ as a benchmark and perform some sensitivity analysis with values in the range [0.5 2].

μ^* is the average markup. Following Hall (1988), we will impose the restriction that the measure of technical progress given by equation (6) has to be orthogonal to a pure demand shock. This is implemented by imposing Cov $(x_t(\mu^*), \varepsilon_{gt}) = 0$, where ε_{gt} is the residual of fitting an AR(1) process with $\rho_g = 0.95$ to the detrended government expenditure series. This parameter is estimated by GMM for the set of countries using data from OECD Main Economic Indicators for the period 1979:1-1993:4. We assume that technical progress follows a stationary process around a linear trend, and therefore $\hat{h}, \hat{y}, \hat{w}$ and $\hat{g}$ are computed as log deviations from that trend. $\hat{y}$ is Gross Domestic Product, $\hat{h}$ is total hours worked per quarter, $\hat{w}$ is average weekly earnings and $\hat{g}$ is total government spending.

The results of our exercise appear in Table (1). Our estimates of the average markup lie in the range [1.32 1.56]. These results are a bit lower than estimates obtained using panel data (at least for the U.S. economy), and therefore some microeconomic analysis should be carried out in order to confirm these values.

The plots (see Figure (1)) and correlation coefficients (Table (2)) seem to suggest that markups are countercyclical. In order to properly check this issue, we present in Table (4) the values of the contemporaneous correlation coefficient between output and markups for different values of μ^* and e. In all cases except for France the values are negative, increasing with μ^* and decreasing with e. This sensitivity of the results to the parameters suggests that further empirical work is needed to put the cyclical properties of markups on a clear stand. In order to explore more in depth the cyclical properties of markups, Table (2) shows the contemporanous correlations of markups with some domestic variables. We can see that in general all variables except government spending and net exports are countercyclical with respect to markups. In terms of averages, consumption is more countercyclical (mean correlation:-0.35) than investment (-0.27) and labor (-0.11). Imports are more countercyclical than exports and therefore net exports are procyclical. Finally, the terms of trade are slightly countercyclical, with a mean correlation of -0.16. The correlations of markups at an international level do not display a clear pattern of behaviour. We can see in Table (3) that the cross-country correlation coefficients range from -0.54 between France and Canada to 0.80 between Canada and the U.S. However, we can see two groups of countries in which correlations are high and positive. Not surprisingly, these groups are: Australia, Canada, U.K., U.S. and Japan on the one hand and Germany, France and Italy on the other. Therefore, we do not find evidence of correlated markup shocks as a way of transmission of business cycles across countries, although it can be significantly important within these groups of countries.

3 The model

The theoretical economy we use extends the standard model of BKK(1993) to include government spending, indivisible labor and imperfect competition. There are two countries, each of which specializes in the production of one tradable good. We assume that there are increasing returns to scale and noncompetitive behaviour in the goods markets and competitive behaviour in the production factors market.

Countries are populated by a large number of utility maximizers infinitely-lived identical agents. The household sells the services of capital and labor at rental prices r_t and w_t respectively, owns all the firms and receives all the profits. The differentiated goods produced by the monopolistic firms will be purchased by the household to be consumed or invested. There are complete financial markets within countries and free mobility of physical and financial capital across countries. However, labor is immobile internationally.

Each household in country h has preferences given by the utility function

$$U_{ht} = E_0 \left[\sum_{i=0}^{\infty} \beta^i u(c_{ht+i}, G_{ht+i}, l_{ht+i}) \right] \tag{10}$$

where U_{ht} is the total discounted lifetime utility, E is the conditional expectations operator and β is the subjective discount factor. The instantaneous utility function, $u(.)$, is given by

$$u_h(c_{ht}, l_{ht}) = \log c^*_{ht} + D \log l_{ht} \tag{11}$$

where c_{ht} is per capita consumption of the final aggregate good at time t, l_{ht} is leisure. D is a constant and $c^*_{ht} = c_{ht} + \phi_g G_{ht}$ is a measure of consumption. We allow the agents to derive some utility from government spending, in particular that government spending has some effect on the marginal utility of consumption as measured by the parameter ϕ_g. If $\phi_g = 1$ then private and government consumption are perfect substitutes and government just crowds out private consumption, whereas if $\phi_g = 0$ government consumption has no effects on private utility and government expenditure can be thought just as a drain of resources. If $0 < \phi_g < 1$ consumption and government consumption are imperfect substitutes and therefore it is costly for society to have government producing these goods. As Canova (1993) points out, a way to see this is to assume that the government has a linear technology of the type $z_t = \phi_g G_t$. If $\phi_g < 1$, production of these goods by the government is inefficient.

The endowment of time is unity in each period, which constrains leisure to be between 0 and 1. This choice is further restricted by the introduction of an indivisible labor structure [2] : the household can either work a fixed amount of time or not to work at all. Following Rogerson (1988) and Hansen (1985), we convexify the consumption set by adding lotteries to the commodity space. In particular, during period t the representative household can either work full time (h_0 hours, $0 < h_0 < 1$) with probability π_t or not work at all with probability $(1 - \pi_t)$. Ex-post, π_t will be the actual number of people working and hence per capita hours will be $h_t = \pi_t h_0 = 1 - l_t$. The utility function of the representative agent is then,

[2] This is justified by the fact that in the U.S. about 2/3 of the volatility of total hours worked appears to be due to movements into and out of the labor force, while the remainder is due to adjustment in hours worked by employees, and this percentage is even larger in Europe. Therefore, it seems that the indivisible labor structure can be an appropriate characterization of labor markets in an international business cycle model.

$$u_{ht} = \pi_t \left(\log c^{\star}_{ht} + D\log(1-h_0)\right) + (1-\pi_t)\left(\log c^{\star}_{ht} + D\log 1\right) \qquad (12)$$

which substituting for leisure simplifies to the following expression:

$$u(c_{ht}, l_{ht}) = \log c^{\star}_{ht} + \frac{D\log(1-h_0)}{h_0} - \frac{D\log(1-h_0)}{h_0} l_{ht}$$

We can see that, due to the indivisible labor structure, the intertemporal aggregate elasticity of substitution of leisure is infinite and independent of the individual preferences.

There exists a continuum of potentially producible different goods indexed by the positive real line, and only $[0\ I_t]$ are produced at each time t. There are j sectors in the economy. In each sector there is a representative firm j that produces good j using capital (K) and labor (H) according to the following value-added increasing returns to scale production function

$$y_{ht}(j) = \left(A_{ht} K_{ht}(j)^{\alpha} (x_{ht} H_{ht}(j))^{1-\alpha_j}\right)^{\gamma_{knj}} - \Phi_h \qquad (13)$$

Production is subject to a stationary technological shock A_{ht} that affects equally all sectors. Φ_h represents a fixed or overhead cost component, which permits the existence of increasing returns to scale without generating positive profits on average, a fact that has been documented for the U.S. by Hall(1990) and Summers (1981) among others. The scale parameter $\gamma_{knj} > 1$ also implies increasing returns to scale. x_{ht} represents the state of technology at time t, and in particular an exogenous labour augmenting Hicks neutral deterministic technological progress.

Aggregating across sectors, we obtain the macro value-added production function,

$$y_{ht} = \left(A_{ht} K^{\alpha}_{ht} (x_{ht} H_{ht})^{1-\alpha}\right)^{\gamma_{kn}} - I_{ht}\Phi_h \qquad (14)$$

where I_{ht} is the number of firms. Because we are assuming a representative firm in each sector, I_{ht} can be thought of as the number of different sectors or industries of the economy at any point in time.

Feasibility requires:

$$\begin{aligned} \int H_{ht}(j)d_j \leq H_{ht} \\ \int K_{ht}(j)d_j \leq K_{ht} \end{aligned} \tag{15}$$

The markup ratio, μ_{ht}, represents the inverse of the Lagrange multiplier associated with the requirement that the firm produces a given level of output. It also represents the ratio of factor marginal productivity over factor marginal remuneration (which is different from the ratio of price over marginal costs if materials enter the production function, see Rotemberg and Woodford(1992)) and depends on the degree of substitutability of goods in the market and the degree of market power that firms have. In the case of perfect competition, goods are perfect substitutes and therefore $\mu_{ht} = 1, \forall t$. The existence of imperfect competition implies that goods are imperfect substitutes and thus there exists an efficiency wedge or markup, $\mu_{ht} > 1$, between marginal products and factor prices at the aggregate level. Conditional factor demands in this economy are then given by

$$F_1(K, H) = \mu_t r_t \tag{16}$$

$$x_t F_2(K, H) = \mu_t w_t \tag{17}$$

where F_1 and F_2 are the derivatives of the production function (13) with respect to capital and labour respectively. We will consider exogenous variations in the degree of market power that could arise, for example, from variations in the degree of substitutability between differentiated goods. This implies considering shocks to markups as a source of disturbances that can be transmitted internationally. An alternative route could have been to consider markups as a transmission mechanism of exogenous shocks, and in which case markups would have been determined endogenously. Rotemberg and Woodford (1992) survey several models of endogenous markup determination. These models make different assumptions on the underlying market structure, and make markups dependent on state variables such as output or profits. In our model we assume that markups vary over time according to the law of motion

$$\ln \mu_{ht} = \rho_\mu \ln \mu_{ht-1} + \epsilon_{\mu t} \quad (18)$$

where $\rho_\mu < 1$. Since we are interested in short run fluctuations. the number of firms I_{ht} will be treated as exogenous. although we could argue that long run growth could increase the number of industries in an economy. since firms will enter or exit the market depending on the level of profits. Whenever there are positive profits firms will enter the economy. creating new diferentiated products. and vice versa. Therefore. we are considering adjustment in the number of industries. and not in the number of firms in each industry. However. we will assume that firms do not react rapidly to technological shocks (see. i.e. Cardia and Ambler (1993) or Portier(1994) for specifications with instantaneous entry and exit of firms). This can be implemented by specifying (as it is done. for example. in Rotemberg and Woodford (1992)). a law of motion for the number of firms that follows an ECM process of the type

$$\log I_{ht} = k \log(I_h x_{ht} H_{ht}) + (1-k) \log I_{ht-1} \quad (19)$$

with k small to ensure a slow adjustment. $0 < k < 1$ and $I_h > 0$ is the steady state number of firms in country h. Since I_{ht} grows with x_{ht}. this specification ensures that profits remain zero in the steady state.

Firms accumulate capital goods according to the law of motion

$$K_{h,t+1} = (1-\delta) K_{ht} + i_{ht} \quad (20)$$

where K_{ht} is total stock of capital in country h. δ_h is the rate of depreciation of capital stock and i_{ht} is total investment in country h.

The stationary technological disturbance follows the autoregressive process

$$\ln A_{ht} = \rho_a \ln A_{ht-1} + \epsilon_{at} \quad (21)$$

where $\rho_a < 1$. In addition to consumers and producers. there is a government in each country. The government consumes domestic goods (G_{ht}). taxes national output with a distortionary tax (τ_h) and transfers back the remaining to domestic residents (T_{ht}). Government expenditure is assumed to be stochastic following the process

$$\ln G_t = \rho_g \ln G_{t-1} + \epsilon_{gt} \tag{22}$$

where $\rho_g < 1$. In order to isolate the effects of government expenditure and differently from the optimal taxation literature that models taxes as a stochastic process, we will set tax rates parametrically (see Baxter (1992) for an analysis of stochastic tax rates in an open economy model). Since taxes are distortionary, we will have to make some assumptions at this stage in order to solve for the competitive equilibrium. We will assume that individuals take government actions as given, which is consistent with the existence of a large number of individuals (see King et al. (1988a) for a complete description of how to compute this suboptimal equilibrium). This means that we can solve for the competitive equilibrium by first solving for the individual problem and then imposing the government flow budget constraint, that is given by

$$G_{ht} = T_{ht} + \tau_h Y_{ht} \tag{23}$$

and has to hold on a period by period basis. To allow for balanced growth, we will assume that both government spending and transfers grow with x_{ht}.

It is important to note that this economy encompasses the perfect competition environment, which can be recovered by setting $\Phi = 0$ and $\mu = \gamma_{kn} = 1$.

Forcing trade can be introduced in the model by assuming that a foreign firm is considered a competitor just like any other. This would imply to reduce a country's monopoly power over the supply of its own goods, an issue that has become popular in theoretical models of trade (see, e.g., Helpman and Krugman (1985)). However, the data shows that domestic consumers tend to consume more products from domestic firms than they do from foreign firms (see Shiells et al. (1986)), and therefore we will use a specification that allows for different weights on domestic and foreign goods. Thus we open the economy by assuming that Y_{ht} can be either used domestically or exported

$$Y_{1t} = A_{1t} + \frac{\Pi_2}{\Pi_1} \tilde{A}_{2t} \tag{24}$$

$$Y_{2t} = B_{1t} + \frac{\Pi_1}{\Pi_2}\hat{B}_{2t} \tag{25}$$

where $\hat{A}_{2t}$ and B_{1t} are exports and imports of country 1 and Π_h is the welfare weight associated with country h. $\Pi_1 + \Pi_2 = 1$. We let $A_{2t} = \frac{\Pi_2}{\Pi_1}\hat{A}_{2t}$ and $B_{2t} = \frac{\Pi_1}{\Pi_2}\hat{B}_{2t}$. Imports and domestic market goods are then used in the production of a final domestic market good in each country. V_{ht}, according to a CES technology of the form (see Armington (1969)):

$$V_{1t} = (\varpi_1 A_{1t}^{1-\rho} + \varpi_2 B_{1t}^{1-\rho})^{\frac{1}{1-\rho}} \tag{26}$$

$$V_{2t} = (\varpi_1 B_{2t}^{1-\rho} + \varpi_2 A_{2t}^{1-\rho})^{\frac{1}{1-\rho}} \tag{27}$$

where ϖ_1 and ϖ_2 are parameters regulating the domestic and foreign content of GNP and $1/\rho$ is the elasticity of substitution between domestic and foreign goods. Therefore, this specification, while keeping the differentiation of goods by firms, allows for higher weights on domestic goods than on foreign goods. Moreover, as long as $1/\rho$ is finite this aggregator embodies the idea that consumers regard goods produced by different firms as imperfect substitutes and prefer variety. If $1/\rho$ is infinite, however, the goods produced by different firms are perfect substitutes and therefore homogeneous. The relative price of imports to exports (terms of trade) is then given by:

$$P_{1t} = \frac{\partial V_1/\partial B_{1t}}{\partial V_1/\partial A_{1t}} = \frac{\varpi_2 B_{1t}^{-\rho}}{\varpi_1 A_{1t}^{-\rho}} \tag{28}$$

where $\varpi_1 = (1 - MS)^\rho$, $\varpi_2 = MS^\rho$ and where MS is the average import share in output.

The aggregate resource constraint for the traded goods in the world economy is

$$\Pi_1 V_{1t} + \Pi_2 V_{2t} = \Pi_1(c_{1t} + i_{1t} + G_{1t}) + \Pi_2(c_{2t} + i_{2t} + G_{1t}) \tag{29}$$

Note that when the two countries are equally wealthy in per capita terms, Π_i $i = 1, 2$ measure the number of agents in each country. Therefore, we can meaningfully discuss country size in the model by varying these weights between 0 and 1.

Now we compute a symmetric, stationary, rational expectations, monopolistic competitive equilibrium. The equilibrium is symmetric because all producers produce the same quantity and charge the same price. We first solve the static profit maximization problem of producers. Once equilibrium prices and profits are determined as functions of the states, the representative household's dynamic optimization problem is then solved, taking as given the laws of motion for the aggregate state variables.

We first convert the system into a non-growing stationary representation. This is done by dividing all the variables by the Hicks-neutral technological progress variable x_t. Since the funcional forms allow for balanced growth, all output components will grow at a common rate while hours worked and leisure will not grow at all. Then we solve a pseudo social planner problem in which first individuals take government behaviour as given and then the planner includes the government budget constraint in order to make individual actions consistent with aggregate constraints. As it is well known, this problem does not have a closed form solution and we have to approximate and solve it numerically. Among the many ways of doing this (see Marcet (1993) for a survey) we follow King et al.(1988b) by linearizing the first order conditions around the steady state [3].

We construct 100 samples of 96 periods (the number of quarters of our data) each time drawing shocks from (18), (21) and (22) for each model specification. Each sample is Hodrick-Prescott filtered and standard deviations and cross correlations are computed. Finally, statistics are averaged over the 100 samples to reduce the importance of sampling variability in the comparisons.

[3] The departures from an efficient environment introduced with monopolistic competition and increasing returns to scale create the possibility of multiple equilibria (see, for example, Chatterjee et al. (1993)). In this paper we focus only on situations in which the deterministic steady state exhibits the "saddle-path" property. For the range of parameters considered in this paper, the eigenvalues of the linearized system satisfy the necessary properties.

4 Calibration of the economy

In calibrating the parameters of the model we follow the existing practice of choosing share parameters to replicate long run averages of the data and utility parameters to match estimates obtained in previous empirical studies. The values that we have selected for $\beta = 0.98$, $\delta_k = 0.025$, $\Pi_1 = \Pi_2 = 0.5$ are standard and do not require discussion. h_0, the fixed amount of hours that the household works per day is computed so that it is consistent with the steady state amount of hours worked, $h = 0.33$. Dividing the first order condition for consumption by the first order condition for labor we have

$$\frac{\Omega \frac{\gamma}{\mu} \frac{Y+\phi I}{Y}(1-\alpha)}{(sc+\phi sg)h} = \frac{D\log(1-h_0)}{h_0} \tag{30}$$

Setting the leisure constant D equal to 2 as in Hansen (1985) gives a value of $h_0 = 0.42$.

Evidence on the parameter ϕ_g, the effect of government spending on private utility is scant. Ashauer(1985) found a value of 0.2, and this is the value used by Ravn (1993) or Canova (1993). We will use this value as a benchmark and experiment with values in the range [0 1] in order to see how variations in this parameter affect the results.

Ravn(1993) reports the mean shares of output components for several OECD countries. The mean shares of government expenditures are different across countries, ranging from 10 % in Japan to 28 % in Sweden. However, most countries of his panel are close to 20 % and we will take this value for our simulations. The investment share is then determined endogenously in the model, and the consumption share will be the residual of these two. The values that we obtain for the benchmark parameterization are I/Y =0.26 and C/Y=0.53, which describe reasonably well OECD economies. The constant tax rate will be set to 30 %, implying an amount of steady state transfers of 10 % of GNP.

For the share of imports MS and the elasticity of substitution of the Armington aggregator ρ^{-1} we use standard values suggested in the literature. Empirically, MS varies substantially across countries, normally being higher for smaller countries. Ravn (1993) reports values ranging from 38.6% for Switzerland to 7.7% for the U.S. BKK (1992) use two values (15% and 30%) as a 'normal' and 'large' import share. Here we choose the cross sectional average of the OECD countries 22.5%. (as in Ravn (1993)) for the benchmark case.

Values for ρ^{-1} of 1-1.5 have been generally used in general equilibrium models of trade but they are believed to be lower bounds for the actual value since estimates of this elasticity parameter are downward biased because of large measurement errors (see Whalley (1985)). Zimmermann (1994) obtains an expression for this elasticity in his model that depends on tariffs, transportation costs, import shares and terms of trade. His corresponding estimates for OECD countries are in the range [0.6-13.5], averaging 5.4. In order to compare with previous work, we use 1.5 as in BKK (1992) for the benchmark case.

The next set of parameters is related to the existence of market power. Evidence on γ_{kn} is scarce. Ramey (1989) and Morrison (1990) report estimates that indicate the presence of declining marginal cost in several industries in the U.S. Morrison (1990) estimates jointly the markup and scale parameters and obtains a value of 1.14 for total manufacturing. Because of this scarcity of proper evidence, we will set it equal to 1.2 and will perform some sensitivity analysis. Average markup, μ_{kn}, will be set equal to 1.4, the mean value across countries of our estimates, but some sensitivity analysis will be carried out to check how results vary with μ_{kn}. The overhead cost Φ is set such that profits are zero in the steady state .

α, the share of capital in the production function, is set to 0.36 which is, approximately, the mean value of the share of capital in production for developed countries (see Zimmermann (1994)). Given $\delta_k, \gamma_{kn}, \alpha$ and μ_{kn}, the K/Y ratio is computed endogenously from the first order condition for the capital stock.

The exogenous elements of the economy are assumed to follow a first order Markov process

$$A_{t+1} = C(L)A_t + \epsilon_{t+1} \tag{31}$$

where $A_{t+1} = [A_{1t}, A_{2t}, G_{1t}, G_{2t}, \mu_{1t}, \mu_{2t}]'$ and $\epsilon_t \sim N(0, V)$. We have therefore to choose parameters for C(L) and V, the variance-covariance matrix. It is widely recognized that direct estimation of these parameters is problematic. In our case it is even more difficult, because we would have to estimate a six variable VAR for different countries in which four of the variables are unobservable (technology and markups) and the other, government spending, has been shown to present very different degrees of persistence over time (see Baxter and King (1993)). Therefore, we will follow a different approach (as it is done for example in Baxter and Crucini (1993)) and select the parameters in order to model different scenarios we may envisage. This will also allow us to compare our results with those existing in the literature and isolate the effects of imperfect competition. The benchmark model will be a standard symmetric model. The persistence of the technological process is set to 0.835 and the volatility to 0.007 as in Ravn (1993), since these values are average of the estimated parameters for the major OECD countries [4]. The cross-country correlation is set to 0.25 and the spillover parameter to 0.088 as in BKK(1993).

The persistence of government spending is set to 0.95 and the standard deviation to 0.005 as in Ravn(1993). However, we will also use the values 0.90 and 0.99 in order to study the effects of temporary and permanent shocks, as it is done in Baxter (1992). In the case when coordinated policies are considered, the cross-country correlation coefficient is set to 0.20 in the case of low policy coordination and to 0.60 in the case of high coordination.

As we have seen, markups seem to follow an autoregressive process which is quite likely to be highly persistent, and therefore we choose a persistence parameter of 0.95 and standard deviation of 0.007 as in Rotemberg and Woodford (1992). We will perform some sensitivity analysis on these parameters to check the robustness of the results to these unmeasured parameters. Cross-country correlations are set to zero as a benchmark but given the evidence we will experiment with positive

[4] It is widely known that the Solow residual does not represent accurately the true technology shocks under imperfect competition (see Deveraux et al. (1995) for an analysis). However, because we are not interested in evaluating the amount of output variability that is accounted for by technology shocks, we will keep the standard Solow residual process to isolate the effects of different dimensions of increasing returns on international facts.

(0.25) and negative (-0.25) correlations across countries.

With this parameterization, we will analyze several models driven separately by technology and government shocks. In both cases we will compare the cases of perfect competition, imperfect competition with constant markups and imperfect competition with variable markups. In order to better understand the contribution of imperfect competition to the dynamics of the models, we will also study a model driven solely by markup shocks which will also allow us to check whether markup fluctuations can drive the international business cycle. Therefore, the models we will consider are:

- A standard perfectly competitive model with technological shocks (Model T1).
- An imperfectly competitive model with technological shocks (Model T2).
- An imperfectly competitive model driven by markup shocks (Model M1).
- An imperfectly competitive model driven by technology shocks with variable markups (Model TM1).
- A perfectly competitive model driven by government spending shocks (Model G1).
- An imperfectly competitive model driven by government spending shocks (Model G2).
- An imperfectly competitive model driven by government spending shocks with variable markups (Model GM1).
- An imperfectly competitive model driven by both technology and government shocks (Model TG1)

For each model specification in which there are technology shocks we will consider three subcases: in the first one (named S1) shocks are uncorrelated across countries and there are no spillovers either domestically or internationally. This setup mimics a situation where countries face idiosyncratic disturbances but move together over the business cycle because of trade interdependencies. The second setup (named S2) has correlated shocks and no spillovers. Here we try to mimic a typical situation in OECD countries where nations face somewhat common disturbances but there is very little evidence of lagged transmission of these shocks. In the third setup (named S3) we consider an economy with correlated shocks and spillovers. a scenario which may realistically resemble the economic environment of highly integrated economies like the European Union.

5 Simulation Results

5.1 Models with Technology Shocks

5.1.1 Standard Model with Technology Shocks

In Table (7) we present statistics for a symmetric model with constant returns to scale driven by disturbances to the market technology (model T1). which serves as a benchmark to compare the improvements obtained with alternative specifications. Figure (2) shows the dynamics of the model following the shock. The model works well along some dimensions but there are at least five aspects of the data which are mismatched. First. output. consumption. hours. imports and exports do not fluctuate enough relative to the data. Second. hours. investment and imports are too highly correlated with output while the correlation between exports and output is too small. Third. real wages are strongly procyclical and hours worked and the return to working are too strongly correlated relative to the data. Fourth. consumption is more correlated than output across countries while in the data the opposite is true. Fifth. investment. hours. imports and exports are either negatively correlated or show no correlation across countries. All of these facts emerge because there is only one source of shocks. investment drives the cycle and capital markets are complete. We will focus on these aspects of the models when examining the improvements obtained with alternative specifications.

5.1.2 Standard Model with Technology Shocks and Imperfect Competition

The addition of imperfect competition (model T2) alters the dynamics of the model. The presence of markups and increasing returns to scale tends to amplify the effects of the technology shock. Market power allows firms to set the marginal product of labor higher than the wage and therefore a technological shock, which represents an increase in the effective units of labor that firms hire, produces, in the presence of imperfect competition, an increase in effective labor input that leads to a higher level of investment and raises output more than under perfect competition. The dynamics of the model for the specification S1 appear in Figure (2). We can see that, as a result of the technology shock, output, investment and productivity respond more compared to the perfect competition case, whereas the behaviour of the rest of domestic variables remain unaltered. This larger increase in domestic investment creates a big boom in foreign exports producing, for the same technology differential, a greater increase in foreign output and hours and a smaller decrease in investment.

As a result, output and productivity fluctuate more whereas employment and investment and therefore foreign trade variables fluctuate less. Confirming the results already obtained in closed economy models, the introduction of imperfect competition raises the volatility of productivity above that of hours, solving one of the aspects of the labor market puzzle. Domestic comovements are barely affected as are international ones, and only cross-country consumption correlations increase slightly because although foreign consumption decreases more after the shock it returns faster to the steady state and therefore the path of consumption in both countries is more similar.

These results are robust to reasonable variations in the imperfect competition parameters, the scale parameter γ_{kn} and the average markup, μ_{kn}. Figure (14) shows how second moments vary with different values of these parameters. First of all, we can see that variations in γ_{kn} have almost no effect on the results, just increasing slightly output and investment volatility.

Variations in market power have a more sizable effect on the variables of the model. As average markups increase, output and productivity fluctuate more and investment, hours and the foreign trade variables fluctuate less. This raises the procyclicality of productivity and decreases that of investment, hours and wages. Therefore, increases in market power just amplify the effects of imperfect competition mentioned above although, for values of markup above 1.8, we obtain the counterfactual result that the volatility of output becomes higher than that of investment.

The main effect of imperfect competition is to raise the volatility of all the variables, but raising the volatility of output more than that of the other variables. This implies that the relative volatility of investment, exports, imports, net exports and the terms of trade decreases in spite of increasing in absolute terms. Therefore, our conjecture about the effect of imperfect competition on relative prices was correct, but the increase in variability turns out not to be enough.

5.1.3 Model driven by Markup Shocks

M1 is a model in which the only source of disturbances is shocks to markups. We can see that it works reasonably well along several lines. Compared to the standard model, it fails to reproduce the volatility of hours and average productivity and the procyclicality of consumption, average productivity and wages, but produces procyclical exports and improves international comovements, since it generates positive cross-country correlations of output, average productivity, hours and wages and lowers the negative correlation of investment, imports and exports. The model produces correlations of markups with domestic variables of the right sign, with the only exception of consumption which is procyclical in the model, but the magnitude is always far from the data. If we allow markups to be correlated across countries (columns M1C1 and M1C2 of Table (7)) the results improve in the case of positive correlation, producing positive cross-country correlations for all the variables.

The dynamics of the model are displayed in Figure (3). An increase in markups produced by, for example, a change in the degree of substitutability of goods after a change in the consumer tastes, decreases the rate of return on production factors, and therefore hours and investment decrease creating a recession, an effect in some sense similar to an adverse technological shock. This seems to be in agreement with the empirical evidence about the countercyclicality of markups. Consumption increases slightly at the moment of the shock due to the transfer of resources from investment, but goes down immediately due to the negative wealth effect. The international reallocation of capital goods and the improvement in the terms of trade produces an improvement in net exports. However, as soon as the shocks are transmitted, investment declines in the foreign country before returning to the steady state, and therefore this model generates cross-country investment correlations that are almost positive, and the same happens with imports and exports. A final important aspect is the behaviour of labor markets. A markup shock implies an increase in real wages, that goes along with a decrease in output and productivity, therefore creating countercyclical movements in wages.

5.1.4 Model with Technology Shocks and Imperfect Competition with variable Markups

The combination of technology and markup disturbances (Model TM1) improves the behaviour of the standard model along several lines. The volatility of hours and productivity increases. Hours, productivity and wages are less procyclical, whereas exports become positively correlated with output. Regarding cross-correlations, output, consumption, hours and wages correlations increase, whereas investment, exports and imports are less negatively correlated across countries. The behaviour of the labor market variables also improves, with hours now being substantialy less correlated with both wages and productivity. In addition, the model is now able to replicate not only the sign but also the magnitude of the markup correlations, with the exception of consumption that is still (although less) procyclical and labor which remains too countercyclical. If we allow markups to be correlated (Model TM1C), as in the two groups of countries we have seen in Section 2, the model behaves even better along the same directions.

The main difference in the dynamics of the model relative to the standard model is that now after the shock investment increases quite less, due to the effect of markups, and therefore output increases only moderately. Hours decrease and wages slightly increase. After the impact. both hours. output and investment decrease. becoming even negative before rising again while returning to the steady state. Therefore. the introduction of variable markups reduces the procyclicality of almost all the variables with respect to output.

The effects of the shocks in the foreign country are similarly milder. At the impact investment decreases less than in the standard model. This fact implies that net exports deteriorate less in the home country. although the level of countercyclicality is almost the same. After the impact. investment. hours and output in the foreign country increase in their way back to the steady state. This implies positive cross-country correlations (or at least less negative) in output. investment. productivity and hours.

The sensitivity of these results to variations in the imperfect competition parameters (γ_{kn}. μ_{kn}. ρ_μ and σ^2_{mu}) can be seen in Figs. (15) and (16). As in model T2. variations in γ_{kn} have no qualitative effect on any of the results. Likewise. as μ_{kn} increases the volatility of output increases whereas the volatility of investment. labor and the foreign trade variables decreases. It is interesting to see that there is a sizable effect on the correlation between productivity and output or labor. with the coefficients increasing as the parameter increases. The rest of domestic and international comovements remain essentially unchanged.

Similarly. the choice of the parameters of the markup process does not affect significantly the results. The value of the persistence parameter does not affect volatilitites. and changes only slightly some of the correlations of labor market variables. The volatility of markups has a more sizable effect. although it does not qualitatively affect any of the results. Logically. increases in the volatility of markups increases output and investment volatility and therefore decreases the procyclicality of wages and productivity. Again. the relative volatility of both the terms of trade and net exports decreases for the reasons explained before. By amplifying the effects of the markup shocks. an increase in the volatility of markups make the behaviour of the model converge towards model T2. thus creating positive comovements across countries of aggregate variables.

The last experiment regards the sensitivity of the results with respect to the elasticity of substitution in the Armington aggregator. As in the standard model, an increase in the substitutability of domestic and foreign goods lowers the relative volatility of the terms of trade and raises that of imports, exports and net exports, more than in the standard model but not enough to match the data. By limiting the transmission of the shock through trade, increases in the elasticity of substitution lower the correlation across countries of the main variables.

Hence, the introduction of imperfect competition with variable markups improves the behaviour of the standard model along several lines, lowering the procyclicality of domestic variables, improving the matching of the second moments of labor market variables and increasing the cross-country correlations of the main variables. Moreover, this model with technology shocks and variable markups is also able to replicate the main stylized facts of markups. However, the model is not able neither to raise the relative volatility of foreign trade variables nor to obtain output correlations larger than the correspondent consumption correlations (the risk sharing puzzle). All these results are robust to variations of the imperfect competition and foreign trade parameters within a sensible range.

5.2 Models with Government Spending shocks

5.2.1 Model with Government Shocks and Perfect Competition

Table (8) shows the second moments of a model driven by an aggregate demand shock in the form of an increase in government spending (Model G1). This model is able to account for some of the volatilities of domestic business cycles. The variability of output is quite low, but the relative variabilities with respect to output are reasonably well reproduced by the model, with the exception of hours, that fluctuate too much. Foreign trade variables are more volatile than in a model with technological shocks and are close to those found in the data.

Domestic comovements do not match the data well, since the model fails to capture the procyclicality of consumption, productivity, wages and exports and produces low saving-investment correlations. However, the model does a good job as far as international comovements are concerned, since it creates positive correlations across countries in output, consumption, investment, hours and wages. Furthermore, with $\phi_g > 0$ the model is also able to solve the risk sharing puzzle, producing consumption correlations that are lower than output correlations. However, imports and exports remain negatively correlated. It is important to note that the high saving-investment correlations are not a property of a perfectly competitive model driven by government shocks.

However, a model like this one should also match the comovements of government spending with domestic variables in order to be meaningful. This is an exercise that, to the best of our knowledge, nobody has done so far, and that is crucial if we want to extract quatitative conclusions from the models. Therefore, we report in Table (6) the contemporaneous correlations of government spending with domestic and forcing trade variables for the main OECD countries plus the European Union. We can see that, although there is not a clear pattern of comovement across countries, we can disinguish some idiosyncracies. In general the coefficients are quite low in absolute value, in particular for the U.S. and Japan, but the European Union semms to be more depending on government spending and displays significantly larger coefficients (all positive) than the rest of countries. The U.K. is another interesting case because all the variables are countercyclical with respect to government spending. Regarding forcing trade, imports are positively correlated with government spending, exports do not display a clear pattern (the range is [-0.49 0.29]), net exports are therefore negatively correlated with government spending whereas the terms of trade are positively correlated. The matching of the model is not very good, because it produces highly procyclical output, investment and hours and highly countercyclical consumption. Regarding forcing trade variables, the model is able to replicate the behaviour of quantities, because it produces net exports which are negatively correlated with government spending due to highly "procyclical" imports and more "neutral" exports. However, the model is not able to replicate the behaviour of prices, because it predicts a highly negative correlation while we find a positive one in the data.

The dynamics of this economy are as follows (Figure (4)). An increase in government purchases increases the world interest rate and produces a negative wealth effect in both countries. The increase in government spending financed by taxes decreases household's income, leading to a decrease in both consumption and leisure. This raises labor supply and lowers wages, and therefore increases the return on capital and investment. Neither national production nor national savings are enough to cover this investment boom, and therefore imports increase substantially. Therefore, on impact there is a small decrease in consumption and an increase in hours, investment and output in both countries due to the perfect capital markets assumption. In a one good world, the responses in both countries would be identical. In this economy with two goods and imperfect substitution between them the responses are similar but not identical, and therefore we obtain positive comovements across countries. The only cross-correlations that remain negative are imports and exports, because in the foreign country imports increase to meet the investment boom whereas exports decrease. The foreign country does not need an increase in imports because the investment boom is small, and therefore we have asymmetric movements in these variables. As we have already said, the model is not able to replicate the behaviour of the terms of trade. This is so because in the model, a government spending shock increases interest rates, and therefore there is an inflow of capital that raises the exchange rate and leads to a deterioration of the terms of trade. However, there are other factors that are not present in the model and which may affect the exchange rate in the opposite way, as for example risk premium or expectation effects, and it seems from the evidence that the final outcome has been dominated by these latter effects. Thus, we have uncovered another puzzle related to the terms of trade that this model is not able to solve.

Modifications of the parameter ϕ_g, the effect of government spending on private utility have a significant effect on the performance of the model, in particular as ϕ_g approaches 1. An increase in the degree of substitutability of government goods decreases (increases) output (consumption) volatility, and when ϕ_g tends to 1 output (consumption) volatility is equal to zero (goes to infinity). This is so because if private and public goods are perfect substitutes and increase in government spending just crowds out private consumption, leaving output unaltered. A second effect of increasing ϕ_g is a lowering in the countercyclicality of consumption, productivity and wages, these last two becoming procyclical. This happens because output is unaltered in this case and therefore consumption now is uncorrelated with output.

It is interesting to note that the correlation between saving and investment is quite low, and decreases with φ_g. An increase in government purchases in this economy increases output and decreases consumption, leading to a small increase in savings (S=Y-C-G), but pushes up investment, creating a gap between these two variables that will be filled by imports. As φ_g increases this gap widens, lowering the correlation.

An interesting property of the model with φ_g different from zero is that we obtain cross-country consumption correlations that are lower than the corresponding cross-country output correlations, although we need values of φ_g larger than 0.6 to obtain consumption correlations similar to those found in the data.

Variations in φ_g affect the dynamics of the model as follows: as φ_g increases, consumption decreases more whereas output, hours, investment, imports and exports increase less, thus leading to a smaller decrease in net exports. As φ_g approaches 1 only consumption is affected and the rest of the variables remain unchanged.

5.2.2 Model with Government Shocks and Imperfect Competition

The introduction of imperfect competition and increasing returns to scale (Model G2) modifies some of the results. It lowers the volatility of consumption, hours and productivity and raises that of output and investment, increasing also the procyclicality of investment and therefore of imports and exports.

International comovements are perhaps the most affected by the introduction of imperfect competition, because all correlations increase, and now even imports and exports display positive correlations. Therefore, this model is able to replicate the pattern of positive cross-country correlations, a fact that the model with perfect competition was not able to do.

The dynamics of this model are displayed in Figure (5). The existence of imperfect competition amplifies the interest rate effect of the government shock and hence produces a larger response of investment and therefore of output. This larger increase in investment is covered by an also larger increase in imports, and therefore consumption decreases only slightly more than under perfect competition. This larger expansionary effect in the home country is also translated to the foreign country, where again investment, output and imports are the most affected. This creates an increase of exports in the home country (instead of a decrease as it was under perfect competition) and this is why we obtain positive correlations across countries of output, investment, imports and exports. The correlations of the foreing trade variables with government spending remain essentially the same, and thus the new terms of trade puzzle is robust to the presence of imperfect competition. Quantitatively, the presence of imperfect competition almost doubles the effect of government spending on both net exports and the terms of trade.

Regarding the saving-investment correlation, the introduction of imperfect competition affects only output and investment, but not consumption. Therefore, for a given increase in government purchases investment grows more but so does output, boosting savings (and increasing the saving-investment correlation) and deteriorating less the balance of trade. Therefore, we can obtain high saving-investment correlations in a model with government shocks if we allow for imperfect competition.

The sensitivity of these results to variations in the scale parameter and in average markups can be seen in Figure (17). As in the case of technological shocks, variations in the scale parameter have no significant effect in any of the second moments. Variations in the degree of market power only affect the behaviour of productivity. For values of μ_{kn} smaller than 1.4 the correlation between productivity and output or hours is -1. However, this changes for values greater than 1.4, increasing as μ_{kn} increases and reaching values of +1 for μ_{kn} greater than 1.8. We have also checked the sensitivity of the results to variations in the foreign trade parameters, MS and ρ^{-1}. The results (not reported to save space) and, in particular, the terms of trade puzzle, are robust to changes in these parameters.

5.2.3 Model with Government shocks and Imperfect Competition with variable markups

If we let markups to be variable (Model GM1) we obtain some interesting results (see Table (9)). In particular, we obtain a more realistic economy in terms of the volatility of output and consumption, although hours and investment are still a bit too volatile. Consumption and productivity are now less countercyclical, and with sufficiently larger markups ($\mu_{kn} > 1.8$) they turn to be procyclical. We still obtain positive comovements across countries, with coefficients that now are lower and therefore closer to data. When $\varphi_g = 1$ we also obtain output correlations that are larger than consumption correlations. The matching of government spending moments is definitely improved. All the coefficients are now quite lower and in line with the data, with the only exception of consumption that is still countercyclical. The correlation with the terms of trade is still negative, but the values are now close to zero and within the range of values found for Italy and Germany. Therefore, we obtain a macroeconomic picture much closer to reality than the standard model driven by government spending shocks, a picture which could compete with the standard model driven by technology shocks.

The dynamics of the model are a blend of the effect of variable markups and government shocks. The effect of variable markups dominate the dynamics, and therefore after the impact the countries are in a situation of recession, with a decrease in investment and hours due to the decrease in rates of return produced by the increased market power of firms. However, as we have seen before, the increase in government spending pushes up interest rates and therefore we have investment, hours and output decreasing less than in the case with only markup shocks. Likewise, consumption decreases more due to the negative wealth effect of government spending. All these movements improve the balance of trade, and thus generate a case in which an increase in government spending does not lead to a deterioration of the balance of trade.

We have checked the sensitivity of this results to the imperfect competition parameters. The left panel of Table (9) shows experiments with different values of markup volatility, persistence and of average markups for $\varphi_g = 0.2$. The results are robust to the different specifications, and if we increase the importance of imperfect competition, either by raising volatility or by increasing average markups, the results improve because we reduce the countercyclicality of both consumption and productivity.

Thus, the introduction of imperfect competition modifies the behaviour of models driven by government spending shocks in several ways, producing interesting quantitative implications regarding the welfare effect of fiscal policies. In addition, accounting for imperfect competition allows the model to replicate the pattern of cross-country correlations and, if we let markups to fluctuate, to replicate also the volatility of output and the correlation of government spending with foreign trade variables.

5.2.4 A comparison between Permanent and Temporary Government shocks

An interesting issue to be analyzed is the distintion between temporary and permanent government spending shocks. This is based on the fact that in general government purchases have had both temporary and permanent components. The permanent component has generally been associated with standard government expenditure whereas the temporary component has been associated mainly with war expenditures (see Baxter and King (1993) for an analysis of the U.S. case and Baxter (1993) for an analysis in a one good model). Our setup allows us to analyze the different behavior of the model in these two cases, defining the shocks as temporary when $\rho_g = 0.90$ [5] and permanent when $\rho_g = 0.99$ as in Baxter and King(1993).

In terms of second moments, we can see from Table (8) that an increase in ρ_g increases the volatility of investment and output. Domestic correlations remain unaltered, with the only exception of the correlation between saving and investment, which increases with ρ_g. Regarding international comovements, cross-country output, hours, productivity, wages, exports, imports correlations increase with ρ_g. The correlations of forcing trade variables with government spending remain untouched.

We can see in Figures (6) and (7) the differences in the dynamics

[5] We have also experimented with $\rho_g = 0.5$ and the conclusions do not change.

of the two specifications (for $\rho_g = 0.2$). A permanent increase in government purchases creates a stronger wealth and interest rate effect, and therefore all the effects of the shock are amplified as ρ_g increases. There is a higher increase after the shock in investment, hours, output and imports, whereas consumption decreases quite more. This also true for the foreign country, and therefore investment in the foreign country grows more, preventing exports in the home country from decreasing. However, imports grow more than exports decrease, and therefore the balance of trade and the terms of trade deteriorate more as the shock becomes more persistent. Quantitatively speaking, with $\rho_g = 0.90$, a unitary increase in government purchases deteriorates the balance of trade by 0.06, whereas with $\rho_g = 0.99$ the deterioration is of 0.1.

The persistence of the shock also affects the behaviour of savings. In the case of temporary government shocks, savings decrease at the impact, whereas with permanent government shocks savings increase on impact. This happens because with a permanent increase in government spending there is a long run increase in interest rates that raises savings whereas a temporary increase just crowds them out. The behaviour of investment is similar to that of savings, with the difference that the imperfect substitution of goods prevents investment from declining after a temporary shock, thus creating a gap between saving and investment. Therefore, the saving-investment correlation is positively correlated with the degree of persistence of government shocks.

The presence of imperfect competition does not qualitatively alter the results. As we have stated before, it amplifies certain responses, in particular those of investment and therefore of net exports, but the main conclusions remain unaltered.

5.2.5 Model with Correlated Government Policies

The current world enviroment suggests that, even though in the past countries have not followed coordinated fiscal policies, it is quite likely that some coordination may arise among groups of countries like the European Union, Mercosur or Nafta. This has led us to make a first attempt to explore the implications of these kind of models when coordinated government spending shocks move the cycle. We have analyzed two levels of coordination, low coordination (corr(G,G*)=0.2) and high coordination (corr(G,G*)=0.6). Given the highly idiosyncratic nature of fiscal policy we do not believe that the levels of coordination will never reach values of correlation too close to one.

The second moments for these experiments appear in Table (10) and the dynamics in Figures (8) to (11). As the level of coordination increases, we can observe an amplification of the responses of investment, output, hours and consumption in both countries, mitigating the deterioration of the trade balance and the terms of trade. This implies that in a framework of highly integrated countries uncoordinated fiscal expansions are likely to have a smaller effect on economic activity and to deteriorate the balance of trade of trading partners, although this could be avoided somehow through coordinated government policies. In addition, apart from the obvious effect of making international comovements more positive, we only observe an increase in output volatility and in the saving-investment correlation and a lowering of the volatility of foreign trade variables, which can be explained by the augmented degree of integration of the economies.

5.3 Model with both Technology and Government Shocks

Finally, after having seen the dynamics and implications of all these different sources of shocks and transmission mechanisms, we want to see how a model driven by both sources of shocks, technology and government spending, works. We can see the results of the simulations in Table (11). In the case of perfect competition (model TG1), the model is similar to that of Ravn(1993) with the added feature of indivisible labor.

As we can see, the behaviour of the model is dominated by the technology shock, but we can note some improvement from the addition of government spending shocks. In particular, if we compare to model T1, we can see that the addition of government spending increases the volatility of consumption and productivity up to realistic levels. The major improvement can be seen in the domestic comovements, because the effect of the government shock is to lower the procyclicality of almost all domestic variables, solving to some extent what we called the "procyclicality puzzle".

It also does a good work, as was shown by Christiano and Eichenbaum (1992) for a closed economy, in solving the "labor market puzzle", driving down the correlation between hours and wages and productivity and almost equalizing the volatilities of labor and productivity. This is improved further with the addition of imperfect competition (Model TG2), and we can see that now productivity is more volatile than hours and that the correlation between hours and productivy is even lower than in model T2 (an imperfectly competitive model with technology shock). Therefore, the combination of both types of shocks and the addition of imperfect competition is a good way of modelling the labor market in an open economy. The government spending facts are well explained by this model, and we even obtain positive correlations with the terms of trade. However, the pattern of international comovements remains unexplained. If we add variable markups (Table (12)), the improvement is again related to labor and productivity, which are now more volatile, less procyclical and more correlated across countries. Cross-country correlations are in general closer to the data, although no significant improvement can be seen in this area. It also lowers the procyclicality of consumption with respect to markups.

Finally, we have experimented with different specifications which included correlated technology and government shocks and positive cross-country correlations of the markup processes combined with nationally correlated technology and markup process. The results, not reported here for reasons of space, did not improve in any way the behavior of the model and, if anything, the performance of the model worsened.

6 Conclusions

In this paper we have explored the implications of introducing imperfect competitions in models of international business cycles driven by technology and government shocks. By presenting some international evidence on markups we have demonstrated that imperfect competition is an issue to be taken into account at the international level. At a theoretical level we can conclude that the introduction of imperfect competition can improve the behaviour of a standard IBC model in several ways.

We have identified five puzzles that a standard international business cycle model driven by technology disturbances leaves unexplained: volatility of foreign trade variables, procyclicality of domestic variables, labor market facts, international consumption risk sharing and international comovements. In order to complete the macroeconomic picture, we have added the correlations of government spending and markup with domestic variables to the set of second moments that we want the models to explain. We have used all these issues as a guide for assesing the performance of the different models we have specified.

The main general effect of considering imperfect competition and increasing returns to scale is an amplification of the responses of the main variables to both technology and government spending shocks, which is generally robust to variations in the scale parameter, average markups and the parameters of the exogenous markup process. This quantitative difference must be taken into account when performing welfare analysis. Specifically, we have seen that, in a standard model with technology shocks, the introduction of imperfect competition lowers the procyclicality of domestic variables, improves the matching of the second moments of labor market variables and increases the cross-country correlations of the main variables. Moreover, this model with technology shocks and variable markups is also able to replicate the main stylized facts of markups. However, the model is not able neither to raise the relative volatility of foreign trade variables nor to obtain output correlations larger than the correspondent consumption correlations (the risk sharing puzzle). All these results are robust to variations of the imperfect competition and foreign trade parameters within a sensible range.

We have also seen that markup fluctuations alone are not able to reproduce the main stylized facts of international business cycles because, although they can reproduce the pattern of volatilities and cross-country correlations, they produce countercyclical consumption and productivity. However, whenever variable markups are introduced into a model the behaviour of the model improves.

Regarding fiscal issues, we have analyze the implications of a standard model driven by government spending shocks under both perfect and imperfect competition, and the modifications implied by variations in the persistence and the degree of coordination of the shocks. Overall, the introduction of imperfect competition modifies the dynamics of the model and produces interesting quantitative implications regarding the welfare effect of fiscal policies. In particular, accounting for imperfect competition allows the model to replicate the pattern of cross-country correlations and, if we let markups to fluctuate, to replicate also the volatility of output. We have confirmed some of the results already obtained in one-good models, as the ability of the model to replicate a situation of "twin deficits", although the corresponding deterioration of the current account is smaller under imperfect competition and under transitory shocks. We have also seen that high levels of saving-investment correlation are not a property of models driven by government shocks, in particular in the cases in which goverment spending affects the utility of consumers and when the shocks are transitory. However, they can be obtained once we introduce imperfect competition or we raise the persistence of the shocks. We have also considered the case of coordinated government polices, and its implications for issues like the deterioration of the trade balance after a fiscal expansion. We have seen that an increase in the degree of coordination amplifies the effects of fiscal expansions and diminishes the subsequent deterioration in the trade balance of trading partners. Finally, we have uncovered a new puzzle that a model driven by government spending shocks is not able to solve, namely the positive correlation found in the data between government spending and the terms of trade. The model consistently produces the opposite sign, and this is robust to variations in the main parameters.

We conclude that imperfect competition seems to be a crucial characteristic to be included in models of international business cycles and although we have modelled it here exogenously, we think that further research should be directed at endogenizing markups and replicating the domestic and international stylized facts of imperfect competition. Some of the models presented in Rotemberg and Woodford (1992) or the model by Gali (1994) could be adapted to the open economy enviroment.

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Table 1: Estimated Average Markup

Australia	Canada	France	U.K.	U.S.	Italy	Japan	Germany
1.47	1.34	1.37	1.42	1.53	1.56	1.41	1.32
(0.07)	(0.03)	(0.11)	(0.09)	(0.12)	(0.15)	(0.08)	(0.10)

Table 2: Domestic Correlations

Country	(μ_{kn},Y)	(μ_{kn},C)	(μ_{kn},I)	(μ_{kn},N)	(μ_{kn},X)	(μ_{kn},M)	(μ_{kn},G)	(μ_{kn},NX)	(μ_{kn},TOT
Aus	-0.39	-0.07	-0.34	-0.24	0.01	-0.11	0.34	0.12	0.22
	0.16	0.07	0.12	0.14	0.10	0.11	0.13	0.10	0.13
Can	-0.12	-0.62	-0.34	-0.35	-0.50	-0.69	-0.09	0.58	0.01
	0.13	0.19	0.10	0.07	0.11	0.07	0.14	0.10	0.13
Fra	0.09	-0.48	-0.22	-0.24	-0.31	-0.52	-0.51	0.36	-0.69
	0.20	0.14	0.22	0.18	0.12	0.14	0.10	0.09	0.07
U.K.	-0.19	-0.63	-0.61	-0.48	-0.19	-0.44	0.37	0.49	-0.20
	0.06	0.02	0.08	0.13	0.09	0.05	0.07	0.00	0.16
U.S.	-0.87	-0.47	-0.03	0.05	0.22	-0.10	-0.13	0.36	0.08
	0.16	0.14	0.13	0.14	0.20	0.10	0.13	0.15	0.09
Ita	-0.21	0.06	-0.22	-0.16	-0.00	-0.28	-0.11	0.35	-0.34
	0.19	0.18	0.16	0.08	0.08	0.16	0.14	0.09	0.11
Jap	-0.48	-0.35	-0.25	-0.24	-0.29	-0.46	0.06	0.41	-0.34
	0.27	0.14	0.23	0.00	0.13	0.16	0.08	0.24	0.17
Ger	-0.10	-0.59	-0.45	-0.30	-0.36	-0.39	-0.12	0.06	-0.16
	0.13	0.15	0.21	0.15	0.10	0.16	0.06	0.22	0.15
Average	-0.30	-0.35	-0.27	-0.11	-0.15	-0.33	0.02	0.18	-0.16

Table 3: International Markup Correlations

	Canada	France	U.K.	U.S.	Italy	Japan	Germany
Aus	0.39	-0.35	0.33	0.49	0.22	0.12	-0.37
	(0.11)	(0.11)	(0.11)	(0.12)	(0.12)	(0.17)	(0.15)
Can		-0.54	0.28	0.80	0.28	0.15	-0.50
		(0.12)	(0.16)	(0.10)	(0.11)	(0.21)	(0.14)
Fra			-0.49	-0.52	0.35	0.02	0.35
			(0.17)	(0.13)	(0.09)	(0.21)	(0.21)
UK				0.43	0.28	0.35	-0.53
				(0.12)	(0.11)	(0.19)	(0.18)
US					0.13	0.38	-0.49
					(0.09)	(0.19)	(0.14)
Ita						0.34	0.15
						(0.12)	(0.08)
Jap							0.09
							(0.21)

Note:Data is from OECD MEI for the period 1979:1-1993:4. Newey-West Standard errors in parentheses.

Table 4: Markup-GNP Correlations

	Aus	Can	Fra	UK	US	Ita	Jap	Ger
				e=0.5				
μ=1.2	-0.48	-0.36	0.07	-0.45	-0.94	-0.41	-0.69	-0.14
	(0.17)	(0.17)	(0.20)	(0.22)	(0.05)	(0.12)	(0.15)	(0.19)
μ=1.4	-0.57	-0.63	0.06	-0.47	-0.95	-0.37	-0.74	-0.22
	(0.15)	(0.13)	(0.12)	(0.21)	(0.04)	(0.16)	(0.14)	(0.18)
μ=1.6	-0.64	-0.79	0.05	-0.49	-0.96	-0.41	-0.77	-0.31
	(0.13)	(0.09)	(0.15)	(0.21)	(0.04)	(0.19)	(0.13)	(0.18)
μ=1.8	-0.68	-0.88	0.04	-0.51	-0.96	-0.43	-0.79	-0.40
	(0.12)	(0.07)	(0.17)	(0.20)	(0.03)	(0.17)	(0.12)	(0.17)
				e=1				
μ=1.2	-0.28	0.12	0.09	-0.19	-0.87	-0.21	-0.48	-0.10
	(0.18)	(0.18)	(0.12)	(0.24)	(0.07)	(0.20)	(0.18)	(0.19)
μ=1.4	-0.39	-0.16	0.08	-0.22	-0.90	-0.25	-0.54	-0.18
	(0.17)	(0.16)	(0.11)	(0.23)	(0.06)	(0.16)	(0.17)	(0.18)
μ=1.6	-0.47	-0.45	0.08	-0.24	-0.91	-0.27	-0.59	-0.26
	(0.15)	(0.14)	(0.13)	(0.23)	(0.05)	(0.12)	(0.16)	(0.18)
μ=1.8	-0.53	-0.66	0.07	-0.25	-0.92	-0.22	-0.62	-0.35
	(0.14)	(0.10)	(0.20)	(0.23)	(0.04)	(0.20)	(0.15)	(0.17)
				e=1.5				
μ=1.2	-0.20	0.28	0.09	-0.09	-0.83	-0.11	-0.38	-0.09
	(0.19)	(0.17)	(0.20)	(0.24)	(0.08)	(0.16)	(0.19)	(0.19)
μ=1.4	-0.32	0.05	0.09	-0.12	-0.87	-0.17	-0.45	-0.16
	(0.17)	(0.17)	(0.14)	(0.24)	(0.06)	(0.21)	(0.18)	(0.19)
μ=1.6	-0.41	-0.23	0.08	-0.14	-0.89	-0.19	-0.49	-0.25
	(0.16)	(0.15)	(0.20)	(0.23)	(0.05)	(0.21)	(0.17)	(0.18)
μ=1.8	-0.47	-0.49	0.08	-0.15	-0.90	-0.18	-0.53	-0.34
	(0.15)	(0.12)	(0.19)	(0.23)	(0.05)	(0.19)	(0.16)	(0.17)
				e=2				
μ=1.2	-0.16	0.36	0.09	-0.04	-0.80	-0.07	-0.33	-0.09
	(0.19)	(0.17)	(0.10)	(0.24)	(0.08)	(0.12)	(0.20)	(0.19)
μ=1.4	-0.28	0.16	0.09	-0.06	-0.85	-0.06	-0.39	-0.16
	(0.18)	(0.16)	(0.12)	(0.24)	(0.07)	(0.21)	(0.19)	(0.19)
μ=1.6	-0.37	-0.10	0.09	-0.08	-0.87	-0.14	-0.44	-0.24
	(0.16)	(0.15)	(0.15)	(0.24)	(0.06)	(0.21)	(0.18)	(0.18)
μ=1.8	-0.43	-0.37	0.08	-0.10	-0.89	-0.19	-0.47	-0.33
	(0.15)	(0.13)	(0.12)	(0.23)	(0.05)	(0.11)	(0.17)	(0.18)

Note:Data is from OECD MEI for the period 1979:1-1993:4. Newey-West Standard errors in parentheses.

Table 5: Benchmark parameter values

β	δ	Π	θ	MS	$1/\rho$	φ_g	Sg
0.98	0.025	0.5	0.36	0.22	1.5	0.2	0.2
μ_{kn}	γ_{kn}	ρ_a	σ_a^2	ρ_g	σ_g^2	ρ_μ	σ_μ^2
1.4	1.2	0.835	0.007	0.95	0.005	0.95	0.007

Table 6: Correlations Government Spending-Domestic variables

	Aus	Can	Fra	Ger	Ita	Jap	Swi	UK	US	EU
Corr(G,Y)	-0.02	-0.31	-0.14	0.02	0.12	-0.10	0.39	-0.27	-0.07	0.31
	(0.15)	(0.15)	(0.18)	(0.17)	(0.15)	(0.11)	(0.10)	(0.11)	(0.17)	(0.10)
Corr(G,C)	0.27	0.08	0.14	-0.07	-0.01	0.06	0.51	-0.25	0.06	0.40
	0.09)	(0.17)	(0.18)	(0.17)	(0.17)	(0.11)	(0.15)	(0.11)	(0.16)	(0.12)
Corr(G,I)	-0.12	-0.34	-0.15	0.12	0.01	-0.15	0.27	-0.11	-0.15	0.38
	(0.16)	(0.14)	(0.18)	(0.17)	(0.18)	(0.11)	(0.17)	(0.17)	(0.17)	(0.09)
Corr(G,N)	-0.18	-0.16	-0.16	0.40	0.08	-0.09	0.14	-0.13	-0.05	0.30
	(0.16)	(0.10)	(0.19)	(0.15)	(0.09)	(0.06)	(0.17)	(0.17)	(0.15)	(0.11)
Corr(G,X)	-0.11	-0.49	-0.04	0.23	-0.15	0.21	0.29	-0.12	0.08	-0.05
	(0.15)	(0.12)	(0.14)	(0.15)	(0.10)	(0.09)	(0.11)	(0.14)	(0.16)	(0.14)
Corr(G,M)	0.12	-0.37	0.08	0.30	0.02	0.06	0.38	-0.07	0.15	0.05
	(0.11)	(0.13)	(0.14)	(0.16)	(0.13)	(0.10)	(0.16)	(0.14)	(0.13)	(0.14)
Corr(G,NX)	-0.17	-0.13	-0.18	-0.13	-0.15	0.13	-0.34	-0.06	-0.05	-0.24
	(0.08)	(0.13)	(0.14)	(0.14)	(0.15)	(0.12)	(0.18)	(0.15)	(0.16)	(0.10)
Corr(G,TT)	0.34	0.49	0.37	-0.02	-0.11	0.15	0.44	0.22	0.44	0.00
	(0.16)	(0.14)	(0.13)	(0.17)	(0.15)	(0.09)	(0.11)	(0.14)	(0.16)	(0.00)

Note: Data is from OECD MEI for the period 1971:1-1993:4, Hodrick-Prescott filtered and in logs. Newey-West standard errors in brackets.

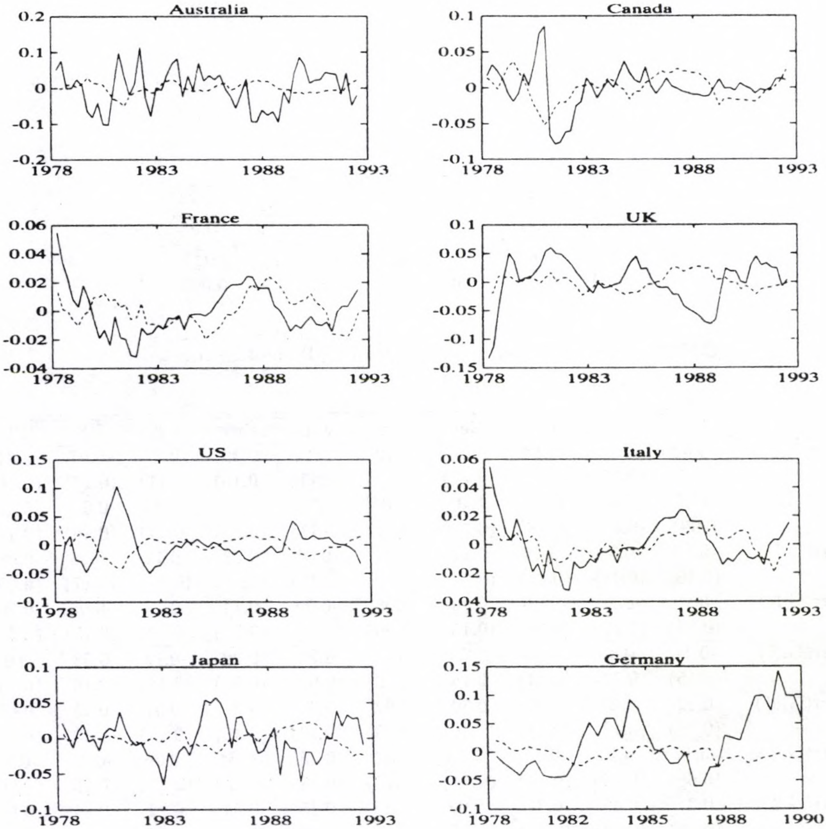

Figure 1: Markups(-) and GNP (- -)

Table 7: Technology and/or Markup Shocks

Model	Data	S1 T1	S1 T2	S1 TM1	S1 TM1C	S2 T1	S2 T2	S2 TM1	S2 TM1C	S3 T1	S3 T2	S3 TM1	S3 TM1C	M1	M1C1	M1C2
STD(Y)	[1.03 1.92]	1.48	2.05	2.57	2.61	1.47	2.04	2.56	2.61	1.40	1.87	2.45	2.50	1.63	1.71	1.54
STD(C)	[0.44 1.17]	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.24	0.26	0.22	0.22	0.15	0.15	0.14
STD(N)	[0.53 1.03]	0.69	0.49	0.79	0.80	0.69	0.48	0.79	0.80	0.64	0.44	0.80	0.81	1.10	1.10	1.09
STD(AP)	[0.76 1.01]	0.34	0.54	0.44	0.43	0.34	0.54	0.44	0.43	0.39	0.60	0.47	0.46	0.11	0.10	0.11
STD(I)	[2.21 3.32]	3.33	2.76	3.09	3.04	3.13	2.59	3.01	2.95	3.15	2.66	3.08	3.02	3.46	3.31	3.64
STD(X)	[2.00 4.76]	1.23	1.01	1.13	1.11	1.19	0.98	1.11	1.09	1.24	1.03	1.15	1.12	1.25	1.18	1.32
STD(M)	[3.08 7.04]	1.29	1.07	1.15	1.12	1.22	1.02	1.12	1.09	1.26	1.07	1.15	1.12	1.24	1.17	1.32
STD(NX)	[0.50 1.27]	0.45	0.37	0.39	0.37	0.39	0.33	0.37	0.34	0.42	0.37	0.39	0.36	0.40	0.33	0.47
STD(TT)	[2.69 7.37]	0.30	0.27	0.24	0.23	0.26	0.24	0.21	0.21	0.23	0.22	0.20	0.19	0.16	0.13	0.19
CORR(C,Y)	[0.42 0.93]	0.66	0.68	0.19	0.11	0.67	0.68	0.21	0.13	0.74	0.72	0.30	0.23	-0.68	-0.78	-0.55
CORR(N,Y)	[0.16 0.68]	0.99	0.98	0.91	0.91	0.99	0.98	0.91	0.91	0.98	0.95	0.89	0.89	1.00	1.00	1.00
CORR(AP,Y)	[0.22 0.88]	0.94	0.98	0.66	0.63	0.94	0.98	0.65	0.63	0.94	0.97	0.62	0.60	-0.87	-0.91	-0.83
CORR(I,Y)	[0.66 0.93]	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.92	0.93	0.94	0.97	0.98	0.97
CORR(X,Y)	[0.04 0.71]	-0.08	-0.08	0.02	0.11	0.15	0.15	0.14	0.24	0.08	-0.04	0.04	0.15	0.18	0.40	-0.05
CORR(M,Y)	[0.18 0.77]	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.97	0.96
CORR(NX,Y)	[-0.08 -0.61]	-0.65	-0.65	-0.60	-0.57	-0.56	-0.56	-0.55	-0.51	-0.58	-0.62	-0.58	-0.55	-0.53	-0.43	-0.62
CORR(TT,Y)	[-0.41 0.43]	0.47	0.50	0.42	0.40	0.41	0.44	0.37	0.35	0.36	0.41	0.35	0.33	0.30	0.25	0.34
CORR(W,Y)	[-0.34 0.65]	0.58	0.62	0.25	0.76	0.68	0.84	0.43	0.76	0.76	0.84	0.45	0.96	-0.49	-0.69	-0.27
CORR(I,S)	[0.10 0.97]	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.99	0.98
CORR(TT,NX)	[-0.59 0.17]	-0.39	-0.41	-0.35	-0.36	-0.38	-0.41	-0.34	-0.34	-0.34	-0.36	-0.31	-0.32	-0.28	-0.28	-0.28
CORR(N,AP)	[-0.87 0.47]	0.88	0.92	0.29	0.26	0.88	0.91	0.28	0.26	0.86	0.84	0.20	0.18	-0.89	-0.92	-0.86
CORR(N,W)	[-0.27 0.57]	0.43	0.43	-0.07	-0.01	0.56	0.70	0.07	-0.01	0.61	0.62	0.04	-0.03	-0.52	-0.71	-0.42
CORR(Y,Y*)	[0.26 0.67]	0.00	-0.03	0.11	0.20	0.25	0.22	0.26	0.34	0.22	0.11	0.20	0.30	0.37	0.56	0.14
CORR(C,C*)	[-0.14 0.70]	0.44	0.55	0.64	0.68	0.61	0.69	0.73	0.76	0.85	0.89	0.87	0.88	0.81	0.88	0.71
CORR(I,I*)	[0.07 0.77]	-0.45	-0.48	-0.26	-0.14	-0.23	-0.27	-0.15	-0.02	-0.37	-0.54	-0.26	-0.12	-0.01	0.23	-0.25
CORR(X,X*)	[-0.08 0.70]	-0.29	-0.29	-0.20	-0.08	-0.05	-0.05	-0.08	0.04	-0.15	-0.28	-0.19	-0.06	-0.06	0.18	-0.30
CORR(M,M*)	[0.16 0.91]	-0.39	-0.40	-0.28	-0.17	-0.16	-0.17	-0.16	-0.05	-0.22	-0.36	-0.25	-0.13	-0.11	0.14	-0.34
CORR(AP,AP*)	[0.10 0.65]	-0.03	0.00	0.01	0.00	0.21	0.24	0.23	0.24	0.46	0.36	0.35	0.36	0.22	0.56	0.14
CORR(N,N*)	[0.10 0.77]	0.01	-0.04	0.26	0.42	0.26	0.21	0.32	0.47	0.07	-0.19	0.26	0.43	0.37	0.61	0.22
CORR(W,W*)	[-0.72 0.77]	0.11	0.07	0.25	0.35	0.34	0.31	0.36	0.46	0.49	0.37	0.38	0.49	0.44	0.38	-0.10
CORR(μ_{kn},Y)	[-0.87 0.12]			-0.59	-0.61			-0.59	-0.61			-0.63	-0.65	-0.98	-0.98	-0.98
CORR(μ_{kn},C)	[-0.63 0.06]			0.41	0.47			0.39	0.45			0.31	0.36	0.75	0.81	0.69
CORR(μ_{kn},I)	[-0.61 0.03]			0.01	0.01			0.01	0.01			0.01	0.01	0.01	0.01	0.01
CORR(μ_{kn},N)	[-0.35 0.05]			-0.85	-0.86			-0.85	-0.86			-0.89	-0.89	-0.98	-0.98	-0.98
CORR(μ_{kn},X)	[-0.50 0.22]			-0.00	-0.17			0.00	-0.16			0.00	-0.17	-0.00	-0.24	0.23
CORR(μ_{kn},M)	[-0.69 -0.10]			-0.65	-0.65			-0.67	-0.67			-0.69	-0.69	-0.99	-0.99	-0.99
CORR(μ_{kn},NX)	[0.06 0.58]			0.42	0.33			0.46	0.36			0.45	0.35	0.67	0.58	0.75
CORR(μ_{kn},TT)	[-0.69 0.22]			-0.11	-0.07			-0.13	-0.09			-0.16	-0.11	-0.37	-0.32	-0.41

Note: TM1C:Corr(μ,μ^*) = 0.25; M1C1:Corr(μ,μ^*) = 0.75; M1C2:Corr(μ,μ^*) = −0.25

Table 8: Government Shocks

Model	Benchmark: $\rho_g = 0.95$						Transitory: $\rho_g = 0.90$						Permanent: $\rho_g = 0.99$					
	G1			G2			G1			G2			G1			G2		
$\phi_g =$	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6
STD(Y)	0.13	0.10	0.04	0.24	0.18	0.08	0.09	0.07	0.03	0.17	0.13	0.06	0.21	0.16	0.07	0.34	0.25	0.11
STD(C)	0.98	1.46	4.22	0.63	0.90	2.48	0.99	1.66	5.65	0.63	1.00	3.15	0.99	1.31	3.07	0.64	0.83	1.94
STD(N)	1.56	1.56	1.56	1.12	1.12	1.12	1.57	1.57	1.57	1.13	1.13	1.13	1.56	1.56	1.56	1.13	1.13	1.13
STD(AP)	0.56	0.56	0.56	0.13	0.13	0.13	0.58	0.58	0.58	0.13	0.13	0.14	0.56	0.56	0.56	0.13	0.13	0.13
STD(I)	3.30	3.28	3.24	3.66	3.65	3.65	2.12	2.01	1.83	3.11	3.06	2.97	4.32	4.36	4.45	4.12	4.15	4.22
STD(X)	1.76	1.84	1.98	1.31	1.35	1.43	1.96	2.05	2.22	1.40	1.44	1.53	1.52	1.58	1.70	1.23	1.26	1.32
STD(M)	1.39	1.43	1.51	1.17	1.19	1.23	1.49	1.54	1.64	1.21	1.24	1.29	1.26	1.29	1.35	1.12	1.14	1.17
STD(NX)	0.54	0.58	0.64	0.33	0.36	0.40	0.63	0.67	0.74	0.38	0.40	0.45	0.43	0.46	0.51	0.28	0.30	0.33
STD(TT)	0.50	0.53	0.58	0.25	0.27	0.30	0.58	0.61	0.68	0.29	0.31	0.34	0.40	0.42	0.47	0.22	0.23	0.26
CORR(C,Y)	-0.99	-1.00	-0.95	-1.00	-1.00	-0.94	-0.99	-0.99	-0.95	-0.99	-0.99	-0.93	-1.00	-1.00	-0.95	-1.00	-1.00	-0.95
CORR(N,Y)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CORR(AP,Y)	-1.00	-1.00	-1.00	-0.99	-0.99	-0.99	-0.99	-0.99	-0.98	-0.96	-0.96	-0.95	-1.00	-1.00	-1.00	-0.98	-0.98	-0.97
CORR(I,Y)	0.99	0.99	0.99	1.00	1.00	1.00	0.95	0.94	0.91	0.99	0.99	0.99	0.99	0.99	0.99	1.00	1.00	0.99
CORR(X,Y)	0.32	0.27	0.20	0.59	0.55	0.48	0.21	0.17	0.09	0.51	0.47	0.39	0.47	0.43	0.35	0.68	0.65	0.59
CORR(M,Y)	0.86	0.85	0.84	0.93	0.93	0.91	0.84	0.83	0.82	0.92	0.91	0.90	0.89	0.88	0.87	0.95	0.94	0.93
CORR(NX,Y)	-0.25	-0.27	-0.30	-0.21	-0.22	-0.24	-0.29	-0.31	-0.34	-0.23	-0.25	-0.27	-0.21	-0.22	-0.24	-0.18	-0.19	-0.21
CORR(TT,Y)	-0.25	-0.27	-0.30	-0.21	-0.22	-0.24	-0.29	-0.30	-0.34	-0.23	-0.25	-0.27	-0.20	-0.21	-0.24	-0.17	-0.18	-0.20
CORR(I,S)	0.65	0.61	0.51	0.89	0.88	0.85	0.35	0.27	0.12	0.82	0.79	0.73	0.86	0.84	0.81	0.94	0.93	0.92
CORR(TT,NX)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.99	0.99	0.99
CORR(Y,Y*)	0.87	0.86	0.83	0.92	0.91	0.89	0.84	0.82	0.78	0.90	0.88	0.86	0.92	0.91	0.89	0.94	0.94	0.92
CORR(C,C*)	0.96	0.77	0.32	0.97	0.82	0.37	0.95	0.67	0.23	0.97	0.75	0.28	0.97	0.87	0.46	0.98	0.88	0.48
CORR(I,I*)	0.76	0.72	0.65	0.87	0.85	0.81	0.84	0.80	0.72	0.89	0.87	0.83	0.80	0.78	0.73	0.88	0.87	0.84
CORR(X,X*)	-0.38	-0.43	-0.52	0.11	0.05	-0.07	-0.51	-0.55	-0.63	-0.02	-0.08	-0.20	-0.16	-0.23	-0.33	0.28	0.22	0.11
CORR(M,M*)	-0.00	-0.06	-0.17	0.42	0.36	0.26	-0.16	-0.21	-0.32	0.31	0.25	0.13	0.23	0.17	0.05	0.55	0.51	0.42
CORR(AP,AP*)	0.88	0.86	0.83	0.91	0.90	0.88	0.84	0.82	0.78	0.90	0.89	0.87	0.92	0.91	0.80	0.91	0.90	0.87
CORR(N,N*)	0.88	0.86	0.83	0.92	0.91	0.89	0.84	0.82	0.78	0.90	0.88	0.86	0.92	0.91	0.89	0.94	0.94	0.92
CORR(W,W*)	0.78	0.76	0.71	0.88	0.86	0.83	0.71	0.68	0.62	0.84	0.82	0.78	0.86	0.84	0.80	0.91	0.90	0.87
CORR(G,Y)	0.85	0.86	0.88	0.83	0.84	0.85	0.87	0.88	0.89	0.84	0.85	0.86	0.83	0.84	0.85	0.81	0.82	0.83
CORR(G,C)	-0.79	-0.90	-0.98	-0.78	-0.88	-0.98	-0.79	-0.92	-0.99	-0.77	-0.90	-0.98	-0.77	-0.86	-0.97	-0.76	-0.85	-0.96
CORR(G,I)	0.90	0.91	0.93	0.86	0.87	0.88	0.79	0.88	0.81	0.82	0.83	0.85	0.88	0.89	0.90	0.85	0.85	0.87
CORR(G,N)	0.85	0.86	0.88	0.83	0.83	0.85	0.86	0.87	0.89	0.83	0.84	0.86	0.83	0.83	0.85	0.81	0.82	0.83
CORR(G,X)	-0.19	-0.22	-0.27	0.06	0.02	-0.02	-0.06	-0.29	-0.33	-0.01	-0.04	-0.07	-0.10	-0.16	0.15	0.12	0.06	0.03
CORR(G,M)	0.99	0.99	0.99	0.97	0.98	0.99	0.99	0.99	0.98	0.98	0.98	0.99	0.99	0.99	0.95	0.96	0.97	0.97
CORR(G,NX)	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.70	-0.69	-0.69	-0.69	-0.69	-0.69	-0.69	-0.69
CORR(G,TT)	-0.70	-0.70	-0.70	-0.70	-0.69	-0.69	-0.69	-0.70	-0.70	-0.70	-0.70	-0.68	-0.68	-0.68	-0.68	-0.68	-0.68	-0.68

Note: STD stands for standard deviation and CORR for the correlation coefficient

Table 9: Model with Government Shocks and Imperfect Competition with Variable Markups

Model	GM1				$\sigma_\mu = 0.009$	$\rho_\mu = 0.99$	$\mu_{kn} = 1.6$
	$\phi_g = 0$	$\phi_g = 0.2$	$\phi_g = 0.6$	$\phi_g = 1$	$\phi_g = 0.2$	$\phi_g = 0.2$	$\phi_g = 0.2$
STD(Y)	1.51	1.50	1.49	1.49	1.89	1.59	1.63
STD(C)	0.17	0.18	0.21	0.25	0.11	0.22	0.16
STD(N)	1.12	1.12	1.12	1.12	1.20	1.12	1.00
STD(AP)	0.13	0.13	0.14	0.14	0.10	0.13	0.05
STD(I)	4.69	4.72	4.77	4.82	5.07	4.72	4.58
STD(X)	1.15	1.15	1.16	1.17	1.31	1.11	1.10
STD(M)	1.18	1.18	1.19	1.20	1.32	1.14	1.15
STD(NX)	0.35	0.35	0.36	0.36	1.48	0.31	0.32
STD(TT)	0.21	0.21	0.20	0.20	0.17	0.20	0.22
CORR(C,Y)	-0.52	-0.50	-0.45	-0.41	-0.47	-0.63	-0.44
CORR(N,Y)	1.00	1.00	1.00	1.00	0.94	1.00	1.00
CORR(AP,Y)	-0.90	-0.90	-0.89	-0.89	-0.76	-0.91	-0.07
CORR(I,Y)	0.97	0.97	0.98	0.98	0.12	0.98	0.98
CORR(X,Y)	0.29	0.28	0.27	0.25	0.21	0.41	0.36
CORR(M,Y)	0.97	0.97	0.97	0.97	0.86	0.98	0.98
CORR(NX,Y)	-0.51	-0.51	-0.52	-0.52	-0.48	-0.46	-0.49
CORR(TT,Y)	0.39	0.40	0.40	0.40	0.33	0.39	0.43
CORR(I,S)	0.97	0.97	0.97	0.97	0.62	0.98	0.98
CORR(TT,NX)	-0.45	-0.46	-0.48	-0.48	-0.34	-0.54	-0.57
CORR(Y,Y*)	0.39	0.38	0.37	0.37	0.29	0.48	0.42
CORR(C,C*)	0.74	0.69	0.53	0.36	0.63	0.81	0.61
CORR(I,I*)	0.07	0.07	0.06	0.06	0.04	0.24	0.14
CORR(X,X*)	0.11	0.10	0.09	0.07	0.07	0.28	0.23
CORR(M,M*)	0.00	-0.01	-0.03	-0.04	-0.00	0.14	0.07
CORR(AP,AP*)	0.23	0.22	0.21	0.20	0.28	0.49	0.43
CORR(N,N*)	0.40	0.39	0.38	0.37	0.47	0.56	0.53
CORR(W,W*)	0.49	0.48	0.46	0.46	0.21	0.36	0.43
CORR(G,Y)	0.13	0.10	0.01	-0.00	0.02	0.10	0.11
CORR(G,C)	-0.48	-0.54	-0.61	-0.65	-0.07	-0.42	-0.55
CORR(G,I)	0.11	0.08	0.04	0.00	-0.00	0.08	0.09
CORR(G,N)	0.13	0.10	0.05	-0.00	0.02	0.10	0.11
CORR(G,X)	0.02	0.01	0.01	-0.01	0.01	0.02	0.03
CORR(G,M)	0.15	0.11	0.05	0.00	0.02	0.11	0.12
CORR(G,NX)	-0.09	-0.07	-0.03	0.00	-0.02	-0.08	-0.07
CORR(G,TT)	-0.13	-0.10	-0.05	-0.00	-0.01	-0.10	-0.09

Note: STD stands for standard deviation and CORR for the correlation coefficient.

Table 10: Model with Correlated Government Shocks ($\phi_g = 0.2$)

	Corr(G,G*)=0.2				Corr(G,G*)=0.6			
ρ_g=	0.99	0.90	0.99IC	0.9IC	0.99	0.90	0.99IC	0.90IC
STD(Y)	0.17	0.07	0.28	0.14	0.20	0.08	0.32	0.16
STD(C)	1.30	1.64	0.83	0.98	1.30	1.61	0.83	0.97
STD(N)	1.56	1.57	1.13	1.13	1.56	1.57	1.13	1.13
STD(AP)	0.56	0.58	0.13	0.13	0.56	0.58	0.13	0.13
STD(I)	4.31	2.01	4.13	3.06	4.25	2.01	4.10	3.05
STD(X)	1.42	1.79	1.18	1.31	1.18	1.36	1.07	1.13
STD(M)	1.20	1.39	1.09	1.17	1.08	1.17	1.04	1.07
STD(NX)	0.38	0.55	0.24	0.33	0.23	0.34	0.15	0.21
STD(TT)	0.35	0.51	0.19	0.25	0.21	0.32	0.12	0.16
CORR(C,Y)	-1.00	-0.99	-1.00	-0.99	-1.00	-1.00	-1.00	-1.00
CORR(N,Y)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
CORR(AP,Y)	-1.00	-0.98	-0.98	-0.96	-1.00	-0.98	-0.99	-0.96
CORR(I,Y)	0.99	0.94	1.00	0.99	1.00	0.94	1.00	0.99
CORR(X,Y)	0.55	0.31	0.74	0.59	0.78	0.61	0.89	0.81
CORR(M,Y)	0.91	0.85	0.96	0.93	0.96	0.92	0.98	0.97
CORR(NX,Y)	-0.18	-0.25	-0.15	-0.20	-0.11	-0.16	-0.10	-0.13
CORR(TT,Y)	-0.18	-0.25	-0.15	-0.20	-0.11	-0.16	-0.09	-0.13
CORR(I,S)	0.89	0.41	0.96	0.86	0.96	0.69	0.98	0.94
CORR(TT,NX)	1.00	1.00	0.99	1.00	1.00	1.00	0.99	1.00
CORR(Y,Y*)	0.94	0.87	0.96	0.92	0.98	0.95	0.98	0.97
CORR(C,C*)	0.91	0.77	0.92	0.82	0.97	0.91	0.97	0.93
CORR(I,I*)	0.85	0.87	0.91	0.91	0.94	0.95	0.97	0.97
CORR(X,X*)	-0.03	-0.40	0.41	0.12	0.43	0.07	0.73	0.54
CORR(M,M*)	0.36	-0.02	0.64	0.42	0.70	0.44	0.85	0.74
CORR(AP,AP*)	0.94	0.87	0.93	0.93	0.98	0.95	0.97	0.97
CORR(N,N*)	0.94	0.87	0.96	0.92	0.98	0.95	0.98	0.97
CORR(W,W*)	0.89	0.78	0.93	0.88	0.96	0.91	0.97	0.95
CORR(G,Y)	0.87	0.90	0.85	0.87	0.93	0.94	0.92	0.93
CORR(G,C)	-0.88	-0.93	-0.88	-0.91	-0.94	-0.95	-0.93	-0.95
CORR(G,I)	0.91	0.81	0.88	0.86	0.95	0.85	0.94	0.91
CORR(G,N)	0.87	0.89	0.85	0.87	0.93	0.93	0.92	0.93
CORR(G,X)	0.09	-0.10	0.31	0.15	0.51	0.34	0.66	0.56
CORR(G,M)	0.99	0.99	0.96	0.98	0.99	0.99	0.98	0.98
CORR(G,NX)	-0.62	-0.62	-0.62	-0.62	-0.43	-0.44	-0.43	-0.44
CORR(G,TT)	-0.61	-0.62	-0.60	-0.62	-0.43	-0.44	-0.42	-0.44

Note: STD stands for standard deviation and CORR for the correlation coefficient. IC marks the models with Imperfect Competition.

Table 11: Technology and Government Shocks

Model	TG1(S1)			TG2(S1)			TG1(S2)			TG2(S2)			TG1(S3)			TG2(S3)		
$\phi_g =$	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6
STD(Y)	1.35	1.36	1.39	1.82	1.85	1.90	1.33	1.35	1.39	1.78	1.82	1.89	1.20	1.23	1.29	1.55	1.60	1.71
STD(C)	0.29	0.29	0.30	0.28	0.28	0.27	0.32	0.31	0.31	0.31	0.30	0.29	0.50	0.48	0.44	0.49	0.47	0.42
STD(N)	0.63	0.63	0.64	0.46	0.45	0.46	0.62	0.63	0.64	0.45	0.45	0.45	0.57	0.57	0.58	0.45	0.42	0.41
STD(AP)	0.44	0.43	0.40	0.61	0.60	0.58	0.45	0.43	0.40	0.63	0.61	0.58	0.58	0.54	0.48	0.75	0.72	0.66
STD(I)	4.41	4.41	4.40	3.63	3.61	3.60	4.17	4.16	4.16	3.43	3.41	3.40	4.36	4.31	4.25	3.76	3.66	3.55
STD(X)	1.12	1.12	1.12	0.91	0.91	0.91	1.11	1.10	1.10	0.90	0.90	0.90	1.20	1.19	1.17	0.98	0.97	0.96
STD(M)	1.22	1.21	1.21	0.99	0.99	0.99	1.17	1.17	1.16	0.96	0.95	0.95	1.26	1.25	1.23	1.04	1.03	1.01
STD(NX)	0.41	0.40	0.40	0.33	0.33	0.32	0.36	0.35	0.35	0.30	0.29	0.28	0.43	0.42	0.40	0.38	0.37	0.35
STD(TT)	0.42	0.41	0.39	0.37	0.36	0.35	0.37	0.36	0.34	0.33	0.32	0.31	0.35	0.33	0.31	0.33	0.31	0.29
CORR(C,Y)	0.63	0.64	0.63	0.60	0.62	0.65	0.65	0.65	0.64	0.61	0.63	0.66	0.67	0.69	0.71	0.59	0.64	0.69
CORR(N,Y)	0.95	0.96	0.98	0.91	0.93	0.96	0.95	0.96	0.98	0.90	0.92	0.96	0.87	0.91	0.95	0.71	0.79	0.90
CORR(AP,Y)	0.91	0.92	0.94	0.95	0.96	0.97	0.90	0.92	0.94	0.95	0.96	0.97	0.87	0.90	0.93	0.91	0.93	0.96
CORR(I,Y)	0.94	0.94	0.95	0.93	0.93	0.94	0.94	0.95	0.95	0.93	0.93	0.94	0.91	0.91	0.92	0.86	0.87	0.89
CORR(X,Y)	-0.01	0.00	0.03	-0.03	-0.01	0.03	0.21	0.22	0.25	0.18	0.20	0.24	-0.02	0.03	0.09	-0.19	-0.12	-0.01
CORR(M,Y)	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.97	0.97	0.96	0.96	0.97	0.96	0.96	0.96	0.95	0.95	0.96
CORR(NX,Y)	-0.64	-0.63	-0.63	-0.64	-0.64	-0.63	-0.55	-0.55	-0.54	-0.56	-0.56	-0.54	-0.63	-0.61	-0.59	-0.68	-0.65	-0.62
CORR(TT,Y)	0.55	0.55	0.54	0.58	0.57	0.56	0.48	0.47	0.47	0.51	0.50	0.48	0.46	0.45	0.43	0.52	0.50	0.47
CORR(W,Y)	0.70	0.73	0.76	0.77	0.81	0.85	0.70	0.73	0.75	0.77	0.80	0.84	0.72	0.75	0.80	0.72	0.77	0.84
CORR(I,S)	0.96	0.96	0.96	0.95	0.95	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.95	0.96	0.96	0.95	0.95	0.96
CORR(TT,NX)	-0.39	-0.40	-0.42	-0.38	-0.40	-0.41	-0.38	-0.40	-0.42	-0.38	-0.39	-0.41	-0.34	-0.35	-0.37	-0.34	-0.35	-0.37
CORR(N,AP)	0.74	0.79	0.84	0.74	0.80	0.87	0.72	0.78	0.84	0.71	0.78	0.86	0.52	0.64	0.78	0.35	0.52	0.74
CORR(N,W)	0.45	0.52	0.60	0.45	0.55	0.67	0.44	0.51	0.59	0.41	0.52	0.65	0.28	0.41	0.58	0.03	0.22	0.51
CORR(Y,Y*)	-0.07	-0.05	-0.01	-0.12	-0.09	-0.04	0.18	0.20	0.23	0.12	0.15	0.20	0.03	0.08	0.16	-0.14	-0.06	0.06
CORR(C,C*)	0.68	0.62	0.47	0.73	0.68	0.54	0.79	0.74	0.60	0.82	0.78	0.67	0.92	0.90	0.82	0.93	0.91	0.85
CORR(I,I*)	-0.48	-0.46	-0.43	-0.53	-0.51	-0.45	-0.28	-0.25	-0.21	-0.34	-0.31	-0.24	-0.60	-0.55	-0.46	-0.76	-0.72	-0.61
CORR(X,X*)	-0.21	-0.19	-0.16	-0.25	-0.22	-0.16	0.03	0.05	0.08	-0.02	0.02	0.08	-0.24	-0.19	-0.10	-0.46	-0.38	-0.25
CORR(M,M*)	-0.36	-0.35	-0.32	-0.41	-0.38	-0.33	-0.14	-0.12	-0.09	-0.19	-0.16	-0.10	-0.34	-0.30	-0.22	-0.55	-0.48	-0.36
CORR(AP,AP*)	0.09	0.05	-0.01	0.02	0.01	-0.01	0.32	0.28	0.23	0.26	0.25	0.24	0.59	0.55	0.49	0.40	0.39	0.37
CORR(G,Y)	-0.02	-0.02	-0.00	0.02	0.01	0.01	-0.02	-0.01	-0.00	0.02	0.01	0.01	-0.02	-0.02	-0.00	0.02	0.01	0.01
CORR(G,C)	0.12	0.10	0.05	0.16	0.12	0.06	0.13	0.10	0.05	0.17	0.13	0.06	0.13	0.10	0.05	0.17	0.13	0.07
CORR(G,I)	-0.09	-0.07	-0.04	-0.09	-0.07	-0.04	-0.10	-0.08	-0.04	-0.10	-0.08	-0.04	-0.10	-0.08	-0.04	-0.09	-0.07	-0.04
CORR(G,N)	-0.08	-0.06	-0.03	-0.06	-0.04	-0.02	-0.09	-0.07	-0.04	-0.07	-0.06	-0.03	-0.11	-0.09	-0.05	-0.08	-0.07	-0.03
CORR(G,X)	0.10	0.08	0.04	0.12	0.09	0.05	0.10	0.08	0.04	0.12	0.10	0.05	0.11	0.09	0.05	0.14	0.11	0.05
CORR(G,M)	-0.24	-0.30	-0.42	-0.20	-0.25	-0.34	-0.22	-0.28	-0.40	-0.19	-0.23	-0.32	-0.15	-0.20	-0.29	-0.13	-0.16	-0.23
CORR(G,NX)	0.08	0.06	0.03	0.12	0.09	0.05	0.08	0.06	0.03	0.13	0.10	0.05	0.08	0.07	0.03	0.13	0.10	0.05
CORR(G,TT)	0.22	0.17	0.08	0.27	0.21	0.10	0.22	0.17	0.08	0.28	0.21	0.10	0.27	0.20	0.09	0.31	0.25	0.11

Table 12: Model with Technology and Government Shocks with variable Markups

Model	TGM1(S1)			TGM1(S2)			TGM1(S3)		
ϕ_g =	0	0.2	0.6	0	0.2	0.6	0	0.2	0.6
STD(Y)	2.30	2.32	2.37	2.27	2.30	2.35	2.11	2.15	2.23
STD(C)	0.24	0.24	0.25	0.26	0.26	0.26	0.38	0.36	0.35
STD(N)	0.80	0.79	0.79	0.81	0.80	0.79	0.85	0.83	0.81
STD(AP)	0.50	0.49	0.48	0.51	0.50	0.48	0.57	0.55	0.52
STD(I)	4.20	4.19	4.18	4.11	4.09	4.08	4.38	4.32	4.24
STD(X)	1.04	1.03	1.03	1.03	1.02	1.02	1.08	1.07	1.06
STD(M)	1.08	1.08	1.08	1.06	1.06	1.06	1.12	1.11	1.10
STD(NX)	0.35	0.35	0.35	0.33	0.33	0.32	0.38	0.37	0.36
STD(TT)	0.32	0.32	0.31	0.29	0.29	0.27	0.28	0.27	0.26
CORR(C,Y)	0.31	0.32	0.33	0.33	0.34	0.34	0.32	0.35	0.39
CORR(N,Y)	0.87	0.87	0.88	0.86	0.87	0.88	0.83	0.84	0.86
CORR(AP,Y)	0.61	0.62	0.64	0.60	0.61	0.64	0.53	0.56	0.60
CORR(I,Y)	0.94	0.94	0.94	0.93	0.94	0.94	0.91	0.91	0.92
CORR(X,Y)	0.09	0.10	0.11	0.20	0.21	0.23	0.03	0.05	0.10
CORR(M,Y)	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
CORR(NX,Y)	-0.59	-0.59	-0.58	-0.54	-0.54	-0.53	-0.61	-0.60	-0.58
CORR(TT,Y)	0.50	0.50	0.49	0.45	0.45	0.44	0.45	0.44	0.43
CORR(W,Y)	0.50	0.52	0.55	0.49	0.51	0.54	0.44	0.47	0.53
CORR(I,S)	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
CORR(TT,NX)	-0.39	-0.39	-0.40	-0.38	-0.39	-0.40	-0.38	-0.38	-0.39
CORR(N,AP)	0.15	0.17	0.21	0.13	0.16	0.21	-0.03	0.02	0.11
CORR(N,W)	0.07	0.10	0.15	0.05	0.09	0.14	-0.08	-0.02	0.07
CORR(Y,Y*)	0.07	0.08	0.10	0.21	0.23	0.25	0.09	0.12	0.18
CORR(C,C*)	0.72	0.67	0.57	0.80	0.76	0.67	0.91	0.89	0.83
CORR(I,I*)	-0.23	-0.22	-0.20	-0.13	-0.12	-0.10	-0.28	-0.27	-0.24
CORR(X,X*)	-0.09	-0.08	-0.06	0.02	0.03	0.05	-0.16	-0.14	-0.10
CORR(M,M*)	-0.23	-0.22	-0.21	-0.12	-0.80	-0.09	-0.28	-0.76	-0.21
CORR(AP,AP*)	0.02	0.01	0.00	0.26	0.25	0.23	0.39	0.38	0.36
CORR(N,N*)	0.28	0.27	0.28	0.32	0.32	0.33	0.27	0.26	0.26
CORR(W,W*)	0.25	0.25	0.27	0.35	0.36	0.37	0.32	0.34	0.38
CORR(G,Y)	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.02
CORR(G,C)	0.12	0.09	0.05	0.12	0.10	0.05	0.12	0.10	0.05
CORR(G,I)	-0.07	-0.05	-0.02	-0.07	-0.06	-0.03	-0.07	-0.05	-0.03
CORR(G,N)	-0.05	-0.04	-0.02	-0.06	-0.05	-0.02	-0.07	-0.05	-0.03
CORR(G,X)	0.10	0.08	0.05	0.10	0.08	0.05	0.11	0.09	0.05
CORR(G,M)	-0.20	-0.24	-0.31	-0.18	-0.22	-0.30	-0.13	-0.16	-0.23
CORR(G,NX)	0.09	0.07	0.04	0.09	0.07	0.04	0.09	0.07	0.04
CORR(G,TT)	0.13	0.10	0.05	0.13	0.10	0.05	0.13	0.10	0.05
CORR(μ_{kn},Y)	-0.60	-0.59	-0.58	-0.61	-0.60	-0.59	-0.66	-0.65	-0.63
CORR(μ_{kn},C)	0.26	0.28	0.31	0.25	0.27	0.30	0.19	0.21	0.24
CORR(μ_{kn},I)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CORR(μ_{kn},N)	-0.87	-0.87	-0.86	-0.88	-0.87	-0.87	-0.90	-0.90	0.90
CORR(μ_{kn},X)	-0.06	-0.06	-0.05	-0.06	-0.06	-0.05	-0.07	-0.06	0.05
CORR(μ_{kn},M)	-0.68	-0.67	-0.66	-0.70	-0.69	-0.68	-0.72	-0.71	-0.70
CORR(μ_{kn},G)	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00
CORR(μ_{kn},NX)	0.42	0.42	0.42	0.46	0.46	0.46	0.43	0.43	0.44
CORR(μ_{kn},TT)	-0.17	-0.17	-0.16	-0.19	-0.19	-0.19	-0.23	-0.22	-0.22

Note: STD stands for standard deviation and CORR for the correlation coefficient.

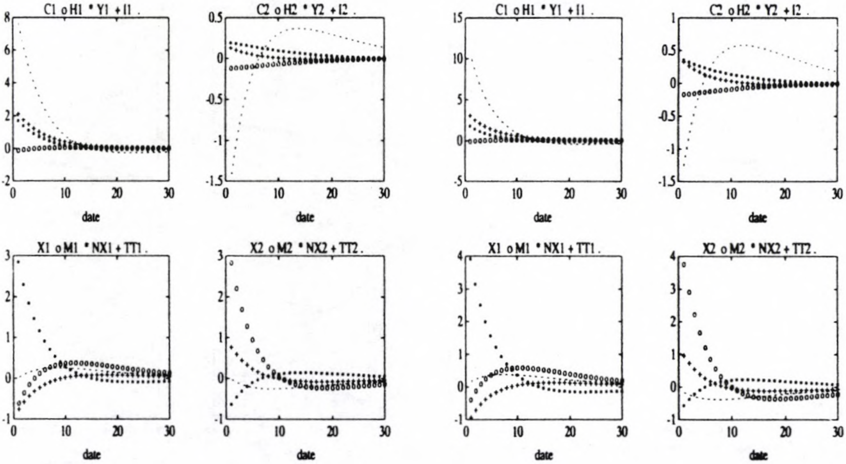

Figure 2: Left panel: Standard Model with Perfect competition (T1). Right Panel: Standard Model with Imperfect Competition (T2)

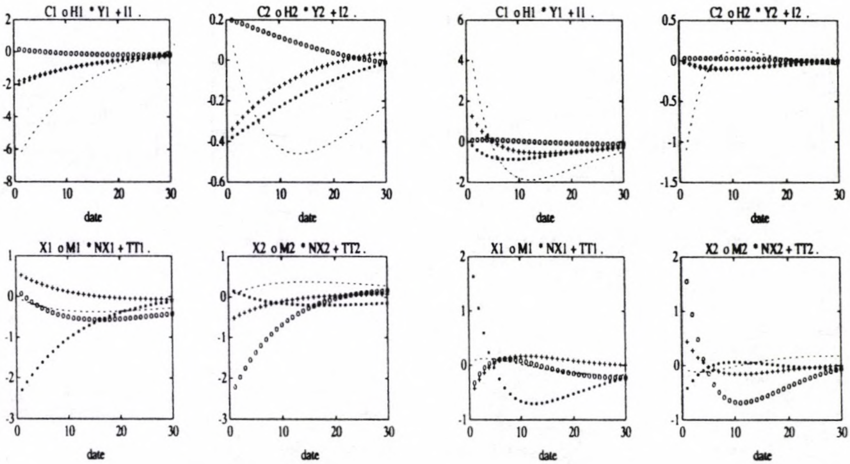

Figure 3: Left panel: Model with only Markup shocks (M1). Right Panel: Model with variable Markups (TM1)

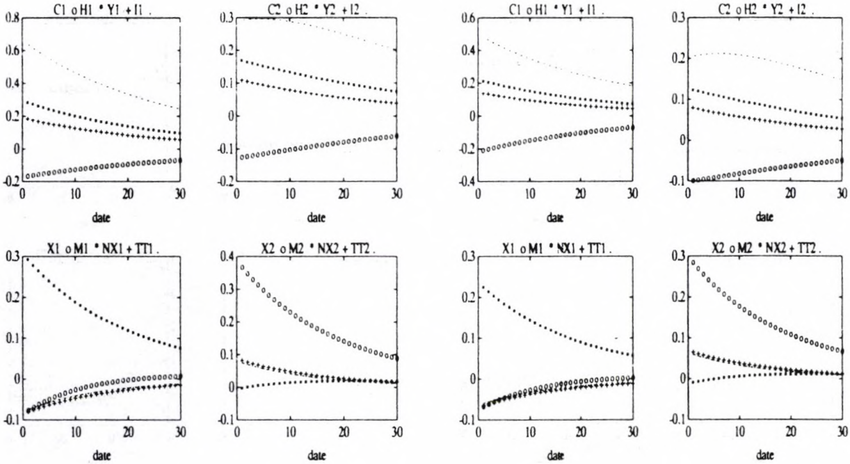

Figure 4: Left panel: Government Shock ($\phi_g = 0$)(G1). Right Panel: Government Shock ($\phi_g = 0.2$)(G2)

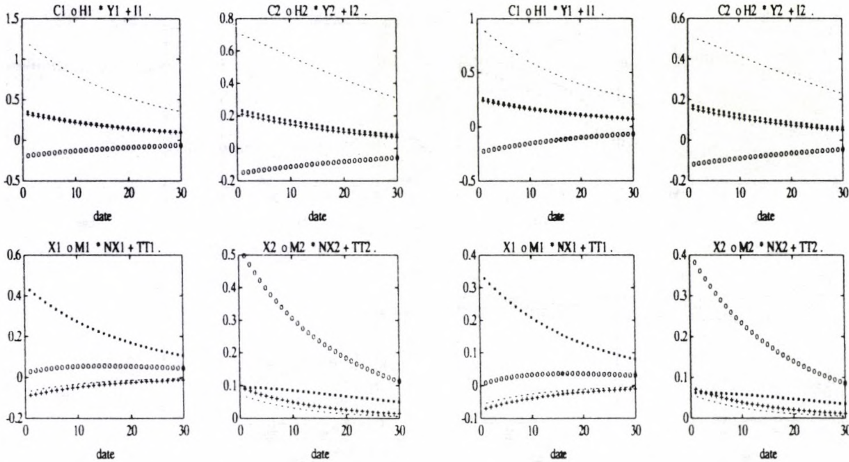

Figure 5: Left panel: Government Shock with Imperfect Competition ($\phi_g = 0$) (G1). Right Panel: Government Shock with Imperfect Competition ($\phi_g = 0.2$) (G2)

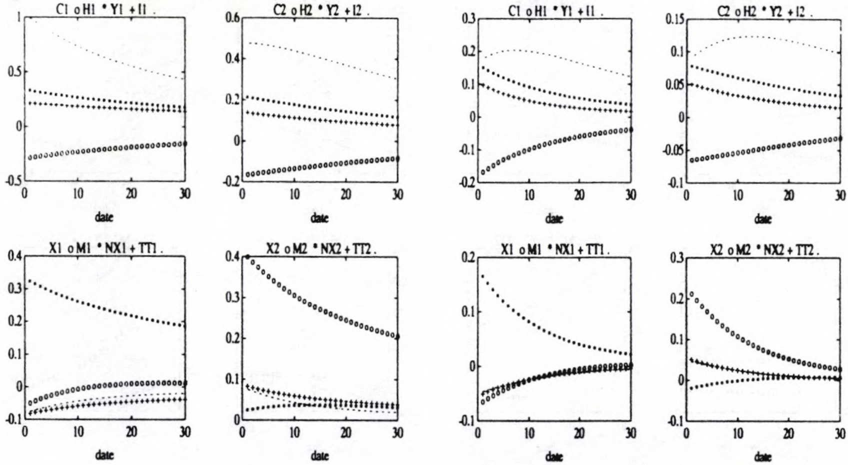

Figure 6: Left panel: Permanent Government Shock ($\phi_g = 0.2$) (G1). Right Panel: Temporary Government Shock ($\phi_g = 0.2$) (G2)

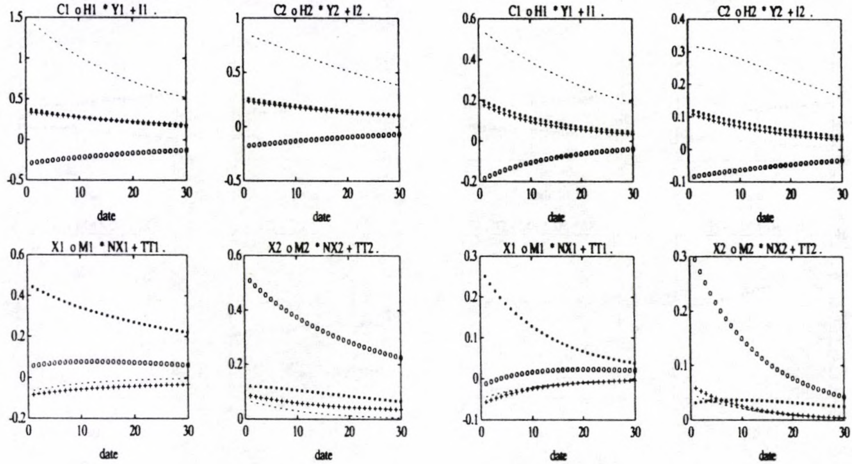

Figure 7: Left panel: **Permanent Government Shock with Imperfect Competition ($\phi_g = 0$) (G1).** Right Panel: **Temporary Government Shock with Imperfect Competition ($\phi_g = 0.2$) (G2)**

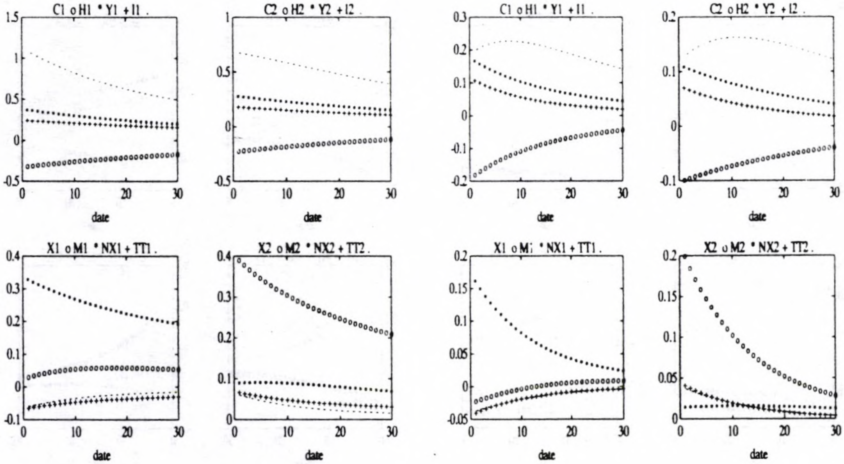

Figure 8: Left panel: Permanent Government Shock (Corr(G,G*) = 0.2) (G1). Right Panel: Temporary Government Shock (Corr(G,G*) = 0.2) (G2)

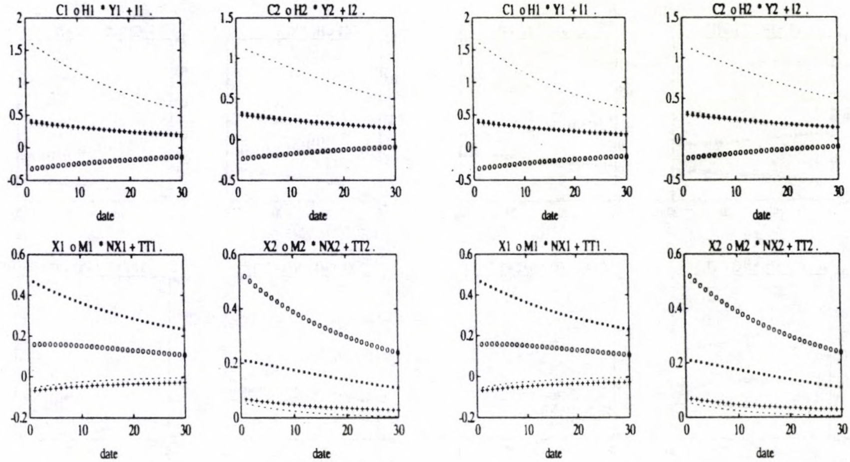

Figure 9: Left panel: Permanent Government Shock with Imperfect Competition (Corr(G,G*) = 0.2) (G1). Right Panel: Temporary Government Shock with Imperfect Competition (Corr(G,G*) = 0.2) (G2)

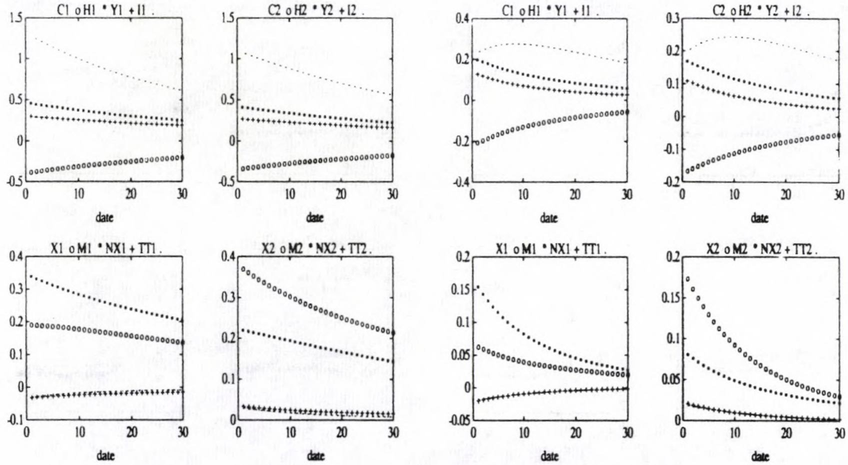

Figure 10: Left panel: Permanent Government Shock (Corr(G,G*) = 0.6) (G1). Right Panel: Temporary Government Shock (Corr(G,G*) = 0.6) (G2)

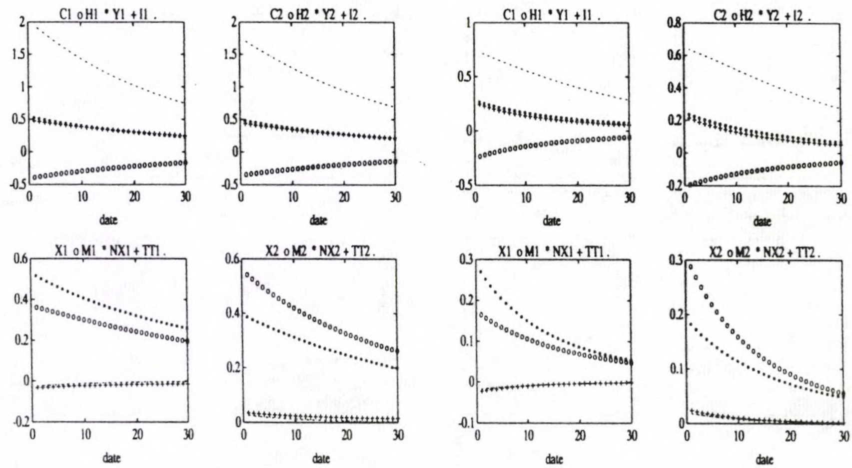

Figure 11: Left panel: Permanent Government Shock with Imperfect Competition (Corr(G,G*) = 0.6) (G1). Right Panel: Temporary Government Shock with Imperfect Competition (Corr(G,G*) = 0.6) (G2)

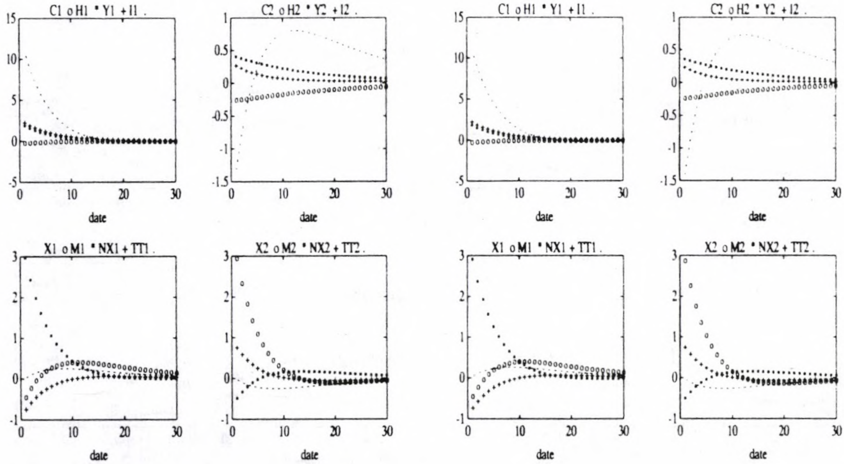

Figure 12: Left panel: Technology and Government Shock ($\phi_g = 0$) (TG1). Right Panel: Technology and Government Shock ($\phi_g = 0.2$) (TG1)

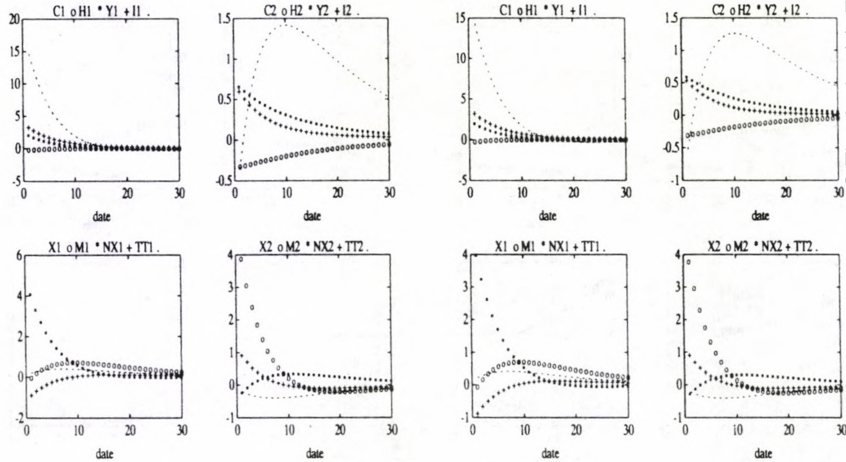

Figure 13: Left panel: Technology and Government Shock with Imperfect Competition($\phi_g = 0$) (TG2). Right Panel: Technology and Government Shock with Imperfect Competition ($\phi_g = 0.2$)(TG2)

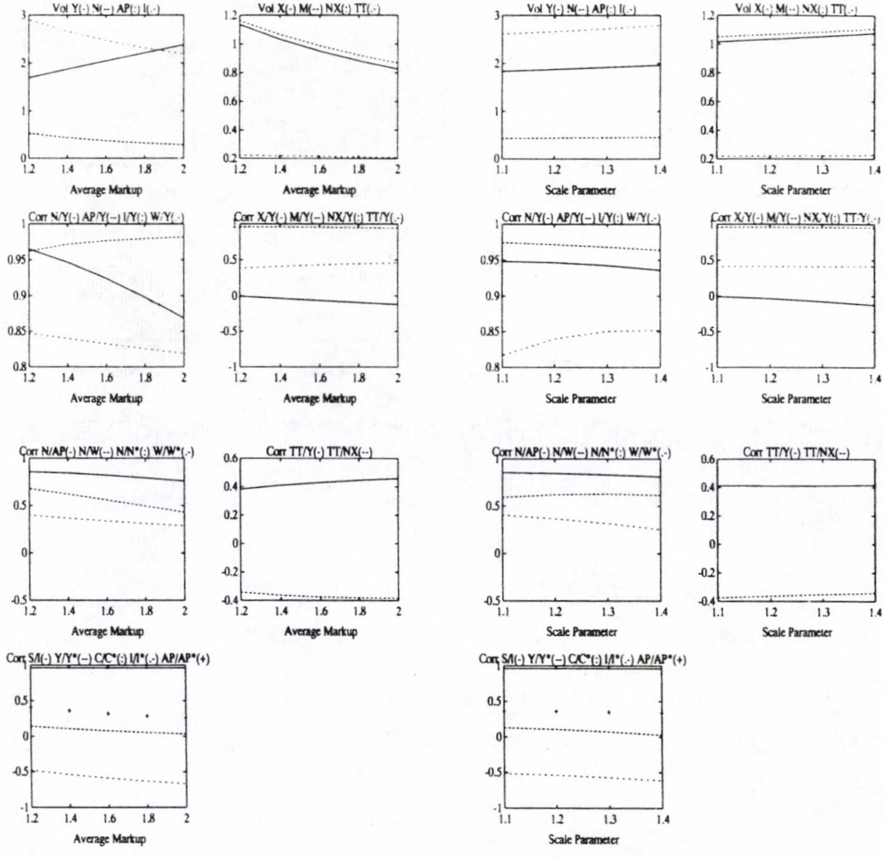

Figure 14: Sensitivity analysis Model T2. Imperfect Competition parameters. Average Markup (left panel) and Scale Parameter (right panel). A * denotes foreign variables.

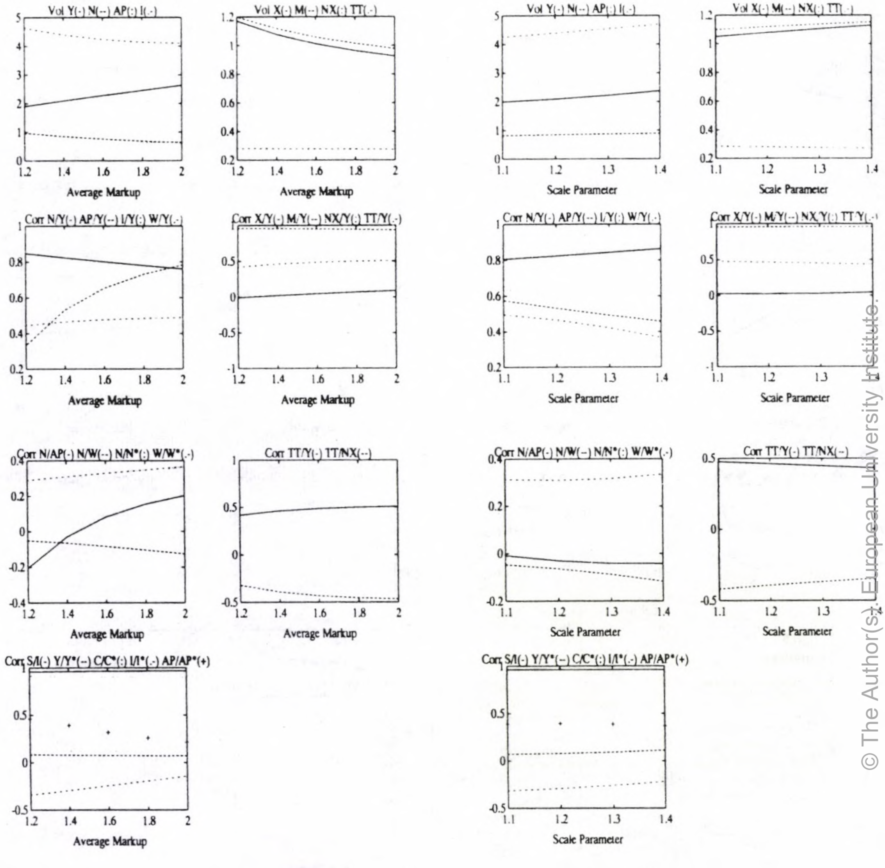

Figure 15: Sensitivity analysis Model TM1. Imperfect Competition parameters. Average Markup (left panel) and Scale Parameter (right panel). A * denotes foreign variables.

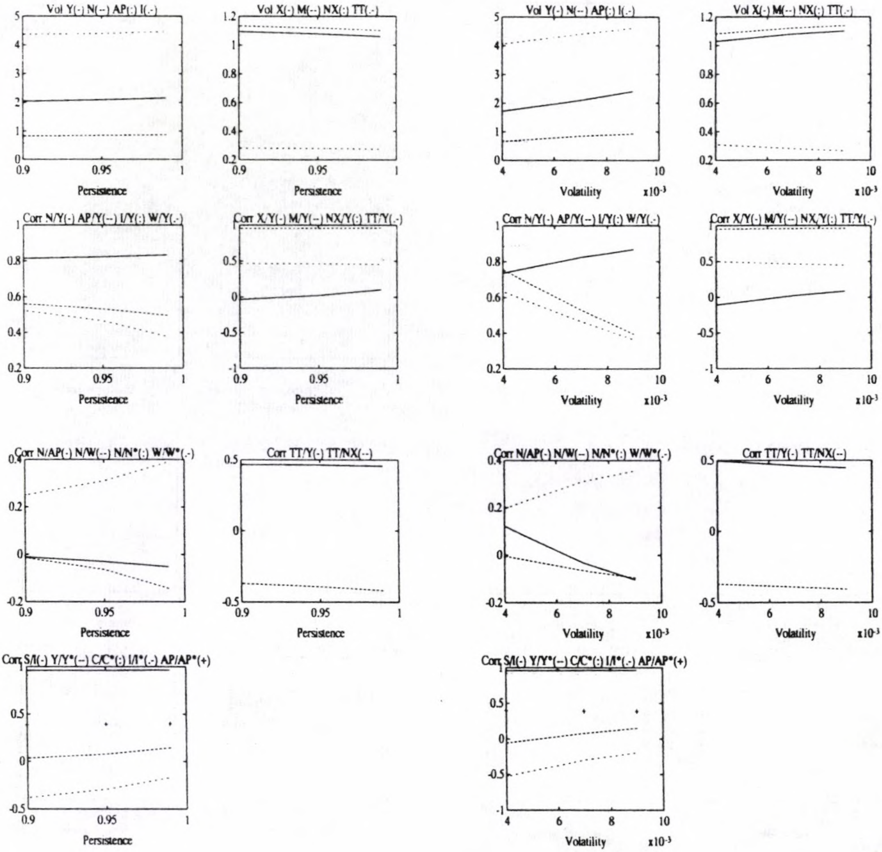

Figure 16: Sensitivity analysis Model TM1. Imperfect Competition parameters. Persistence (left panel) and Volatility (right panel) of the markup process. A * denotes foreign variables.

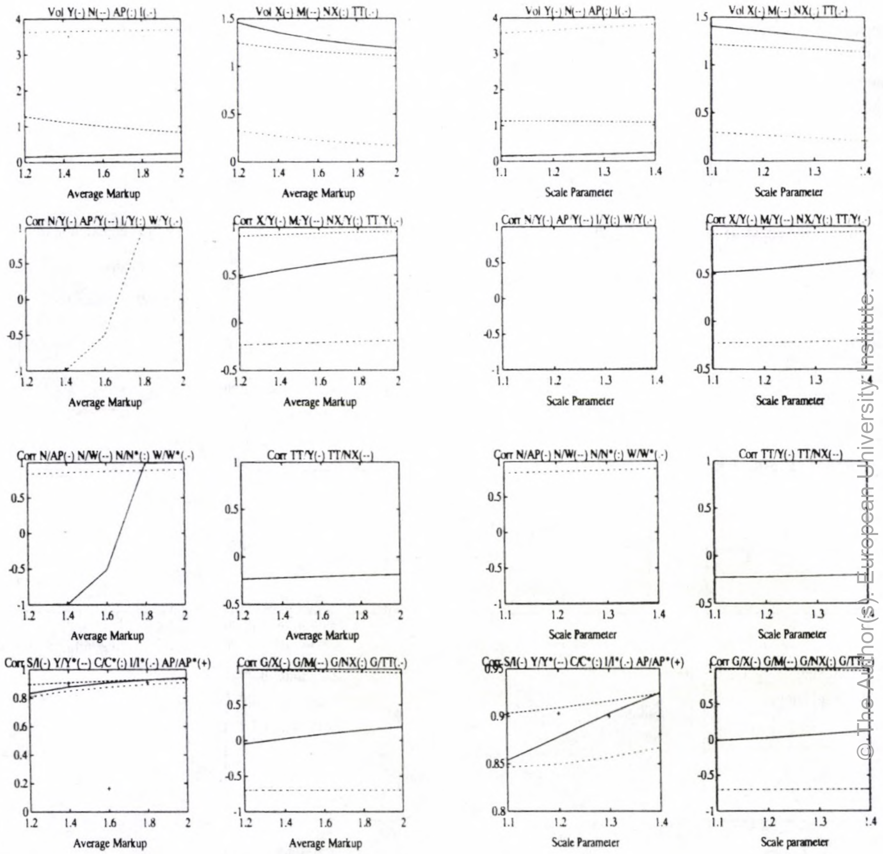

Figure 17: Sensitivity analysis Model G1. Imperfect Competition parameters. Average Markup (left panel) and Scale Parameter (right panel). A * denotes foreign variables.

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