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INTERNATIONAL TRANSMISSION OF SHOCKS IN A BUSINESS-CYCLE MODEL UNDER IMPERFECT COMPETITION

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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 behavior of a standard model driven by technology shocks, although the behavior of foreign trade variables remains unexplained. We also show that an imperfectly competitive model driven by government shocks can explain the international business cycle at least as well as a model driven by technology shocks.

Keywords: Imperfect Competition, International Business Cycles, Markups

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 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 to 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 attempt to study the determinants of aggregate fluctuations in open economies and the transmission of idiosyncratic shocks across countries. For example, Mendoza (1991) has addressed the question of what

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generates aggregate fluctuations in a small open economy. Backus et al. (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 (1998)], multiple sources of transmission of shocks [Canova and Marrinan (1998)], nontradable consumption goods [Stockman and Tesar (1997)], and have studied the properties of these models for trade issues, [J-curve, see Backus et al. (1993)], policy questions [saving and investment correlations, see Baxter and Crucini (1993)] and insurance schemes [see, e.g., Deveraux et al. (1992)]. There also have 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, such as the quantity anomaly (the positive cross-country correlation of the main macro variables) and the price anomaly (the high variability 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 that 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 quantitative 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 a calibrated international business-cycle model with imperfect competition. We consider this a valuable undertaking for three reasons. First, this attempt is supported empirically by the fact that microeconomic studies have provided evidence of substantial markups of price over marginal cost in many industries and countries [see, e.g., Hall (1988), Rotemberg and Woodford (1991), and Ravn (1994)]. Second, imperfect competition modifies the price and substitution mechanisms of the model so as to alter the crucial dynamics governing investment, labor, and the terms of trade. Variable markups shift the labor demand curve, break the perfect-consumption risk sharing across countries, and increase the volatility of imports, exports, and the terms of trade, thus leading to interesting results for issues such as the international transmission of shocks, the behavior of the terms of trade, or the analysis of coordinated government policies. Third, as we have mentioned already, the large majority of papers in the international business-cycle literature focus on supply and/or demand shocks as the driving forces of the economy. We put forward an additional source of shocks and transmission of business cycles: exogenous markup fluctuations. Markup shocks can be the result of changes in the degree of substitutability of goods that could come, for example, from market saturation and consumer pressure or changes in consumers' tastes [see Rotemberg and Woodford (1995)]. It also could be the result of exogenous changes in inflation expectations [see Benabou (1992)]. Thus, we have three types of sources of shocks in our model: supply (technology), demand (government policy), and taste/market structure (markup).

This paper is related to the literature on the dynamic-optimizing approach to the current account, e.g., Obstfeld and Rogoff (1995), and all of its subsequent extensions, including Betts and Deveraux (1996, 1997), Chari et al. (1996), Hau (1997), and Kollman (1997), among others. However, none of those papers includes capital accumulation in the model, despite the fact that international trade is mainly in capital goods, nor performs a quantitative investigation in a two-country world. Rather, their main focus is on the qualitative implications of nominal rigidities for the behavior of exchange rates. 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 extends the two-country, two-good general equilibrium model of Backus et al. (1993) by introducing 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 disturbances. 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 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, although it cannot completely solve the quantity and price anomalies. We also show that the effects of government shocks are quantitatively different with respect to perfectly competitive environments, 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 volatilities and cross-country correlations that we see in the data. Section 6 concludes.

2. SOME STYLIZED FACTS

The first column of Table 5 reports the range values of the main stylized facts for OECD countries for the period 1970:1–1993:4, and is taken from Ubide (1995). Because they are widely known by now, we refer to Backus et al. (1995) for a detailed description and analysis of international business-cycle facts.

In what follows we provide some new international evidence regarding the size and properties of markups across countries. The evidence on markups in the literature is contradictory and refers mainly to the United States. Using value-added data, Hall (1988) reports values of markups above 2 for the United States, whereas Domowitz et al. (1988) use a highly disaggregated panel data set and find values around 1.6. Recently, Norrbin (1994), introducing intermediate inputs in his data set, found markups to be considerably smaller, around 1.1. The only non-U.S. evidence of which we are aware is that of Portier (1994), who finds a markup of 1.37 for France. Therefore, it seems worthwhile to estimate markups consistently for an international data set.

Following Rotemberg and Woodford (1991), markups are computed from the following expression [see Ubide (1996) for details]:

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

where sk and sh are the payments to capital and labor in terms of factor shares and $\hat{y}$, $\hat{k}$, $\hat{h}$, $\hat{w}$, and $\hat{I}$ are output, capital, labor, wages, and the number of firms in log deviations from the steady state; $\hat{y}$ 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.

We could not find data for the rental price of capital and for the number of firms at quarterly frequency and over a long sample, and therefore these terms are dropped from the estimation. However, as Backus et al. (1992) pointed out, the cyclical variability of capital is small compared with that of output so that the omission of this variable from equation (1) 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. To estimate these series, we need values for the parameters e and μ^*.

The elasticity of substitution between factors in the production function, e, is equal to 1 in the case of the Cobb-Douglas production function, and this is the value that we use as a benchmark; μ^* is the average markup. Following Hall (1988), this parameter is computed by imposing the restriction that technical progress has to be orthogonal to a pure demand shock.[1] This parameter is estimated by GMM for the set of countries using quarterly data from OECD Main Economic Indicators

TABLE 1. Estimated average markup[a]

Australia	Canada	France	UK	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)

[a] Newey-West standard errors in parentheses.

for the period 1979:1–1993:4 (in the case of Germany the sample is 1979:1–1989:4 to avoid the effects of the reunification).

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 to confirm these values. The plots (see Figure 1) and correlation coefficients (Table 2) suggest that markups are countercyclical [Ubide (1996) provides some sensitivity analysis for different values of μ^* and e that confirm this result].

To explore in more depth the cyclical properties of markups, Table 2 shows the contemporaneous 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 behavior. 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 United States. However, we can see two groups of countries within which correlations are high and positive. These groups are Australia, Canada, the United Kingdom, the United States, 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 groups of countries.

3. MODEL

The theoretical economy we use extends the standard model of Backus et al. (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 behavior in the goods markets and competitive behavior in the production factors market.

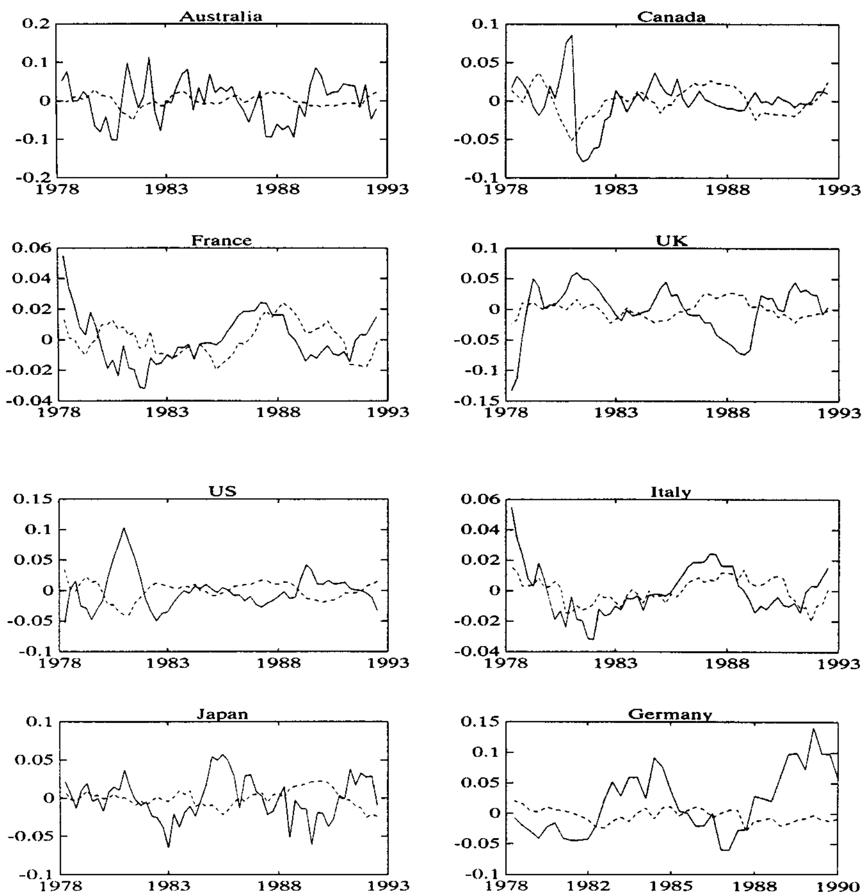

Figure 1. Markups (-) and GDP (- -).

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 of the firms, and receives all of 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

$$U_{ht} = E_0 \left[\sum_{i=0}^{\infty} \beta^i u(c_{ht+i}, G_{ht+i}, l_{ht+i}) \right], \tag{2}$$

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TABLE 2. Domestic correlations[a]

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)
Australia	−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)
Canada	−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)
France	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)
UK	−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)
Italy	−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)
Japan	−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)
Germany	−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

[a] Newey-West standard errors in parentheses.

TABLE 3. International markup correlations[a]

Country	Canada	France	UK	U.S.	Italy	Japan	Germany
Australia	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)
Canada		−0.54	0.28	0.80	0.28	0.15	−0.50
		(0.12)	(0.16)	(0.10)	(0.11)	(0.21)	(0.14)
France			−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)
U.S.					0.13	0.38	−0.49
					(0.09)	(0.19)	(0.14)
Italy						0.34	0.15
						(0.12)	(0.08)
Japan							0.09
							(0.21)

[a] Newey-West standard errors in parentheses.

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 is logarithmic and given by $u_h(c^*_{ht}, l_{ht})$ where $c^*_{ht} = c_{ht} + \phi_g G_{ht}$ is a measure of total consumption, c_{ht} is per-capita consumption of the final aggregate good at time t, l_{ht} is leisure, and G_{ht} is a measure of government spending that has some effect on the marginal utility of consumption as measured by the parameter ϕ_g [see Canova and Marrinan (1998) for the implications of different values of ϕ_g].

The endowment of time is unity in each period. This choice is restricted further by the introduction of the Hansen (1985) indivisible labor structure: The household can either work a fixed amount of time or not work at all.[2] The consumption set is convexified by adding lotteries to the commodity space. In particular, during period t the representative household either can 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 $h_t = \pi_t h_0 = 1 - l_t$.

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). Production is subject to a stationary technological shock A_{ht} that affects all sectors equally. Aggregating across sectors, we obtain the macro value-added increasing returns-to-scale production function

$$y_{ht} = \left[A_{ht} K^{\alpha}_{ht} (x_{ht} H_{ht})^{1-\alpha}\right]^{\gamma_{kn}} - I_{ht} \Phi_h, \qquad \textbf{(3)}$$

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where 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 United States by Hall (1990) and Summers (1981) among others. The scale parameter $\gamma_{kn} > 1$ also implies increasing returns to scale; x_{ht} represents the state of technology at time t, and in particular an exogenous labor augmenting Hicks neutral deterministic technological progress. 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.

The markup ratio, μ_{ht}, represents the inverse of the Lagrange multiplier associated with the requirement that a firm produces a given level of output. It also represents the ratio of factor marginal productivity over factor marginal remuneration 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 then are given by

$$F_1(K, H) = \mu_t r_t, \tag{4}$$

$$x_t F_2(K, H) = \mu_t w_t, \tag{5}$$

where F_1 and F_2 are the derivatives of the production function (3) with respect to capital and labor. We 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, in which case markups would have been determined endogenously. Rotemberg and Woodford (1995) 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,

$$\ln \mu_{ht} = \rho_\mu \ln \mu_{ht-1} + \varepsilon_{\mu t}, \tag{6}$$

where $\rho_\mu < 1$. Because we are interested in short-run fluctuations, the number of firms, I_{ht}, is treated as exogenous, and 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 differentiated products, and vice versa. Therefore, we are considering adjustment in the number of industries, not in the number of firms in each industry. However, we assume that firms do not react rapidly to technological shocks [see Cardia and Ambler (1993) or Portier (1994) for specifications with instantaneous entry and exit of firms].[3] This can be implemented by specifying [as done, for example, by Rotemberg and Woodford (1995)], a law of motion for the number of firms that follows an ECM process of the type

$$\log I_{ht} = k \log (I_h x_{ht} H_{ht}) + (1-k) \log I_{ht-1} \tag{7}$$

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. Because 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,

$$K_{h,t+1} = (1-\delta)K_{ht} + i_{ht}, \tag{8}$$

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 an AR(1) process with parameter $\rho_a < 1$.

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 an AR(1) process with parameter $\rho_g < 1$. To isolate the effects of government expenditure, we set tax rates parametrically. Because taxes are distortionary, we have to make some assumptions at this stage to solve for the competitive equilibrium. We assume that individuals take government actions as given, which is consistent with the existence of a large number of individuals [see King et al. (1988) 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, which is given by

$$G_{ht} = T_{ht} + \tau_h Y_{ht} \tag{9}$$

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

Foreign trade can be introduced in the model by assuming that a foreign firm is considered a competitor just like any other. This would imply reducing 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 show that domestic consumers tend to consume more products from domestic firms than they do from foreign firms [see Shiells and Stern (1986)], and therefore we 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,

$$Y_{1t} = A_{1t} + \frac{\Pi_2}{\Pi_1}\tilde{A}_{2t}, \tag{10}$$

$$Y_{2t} = B_{1t} + \frac{\Pi_1}{\Pi_2}\tilde{B}_{2t}, \tag{11}$$

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where $\tilde{A}_{2t}$ 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 define $A_{2t} = (\Pi_2/\Pi_1)\tilde{A}_{2t}$ and $B_{2t} = (\Pi_1/\Pi_2)\tilde{B}_{2t}$. Imports and domestic market goods then are 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)]:

$$V_{1t} = \left(\omega_1 A_{1t}^{1-\rho} + \omega_2 B_{1t}^{1-\rho}\right)^{\frac{1}{1-\rho}}, \tag{12}$$

$$V_{2t} = \left(\omega_1 B_{2t}^{1-\rho} + \omega_2 A_{2t}^{1-\rho}\right)^{\frac{1}{1-\rho}}, \tag{13}$$

where ω_1 and ω_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) then is given by

$$P_{1t} = \frac{\partial V_1}{\partial B_{1t}} \bigg/ \frac{\partial V_1}{\partial A_{1t}} = \frac{\omega_2 B_{1t}^{-\rho}}{\omega_1 A_{1t}^{-\rho}}, \tag{14}$$

where $\omega_1 = (1 - MS)^{\rho}$ and $\omega_2 = MS^{\rho}$, MS being the average import share in output.

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

$$\Pi_1 V_{1t} + \Pi_2 V_{2t} = \Pi_1(c_{1t} + i_{1t} + G_{1t}) + \Pi_2(c_{2t} + i_{2t} + G_{1t}). \tag{15}$$

Note that when the two countries are equally wealthy in per-capita terms, Π_i $(i = 1, 2)$ measures 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 solved numerically, taking as given the laws of motion for the aggregate state variables. We construct 100 samples of 96 periods (the number of quarters of our data) 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.

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 (see Table 4 for a summary). The fixed amount of hours that the household works per day, h_0, is computed so that it is consistent with the steady-state amount of hours worked, $h = 0.33$. 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 (1997) or Canova and Marrinan (1998). We use this value as a benchmark and experiment with values in the range [0 1].

Ravn (1997) 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 take this value for our simulations. The investment share then is determined endogenously in the model, and the consumption share is 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 is set to 30%, implying an amount of steady-state transfers of 10% of output.

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 (1997) reports values ranging from 38.6% for Switzerland to 7.7% for the United States. Backus et al. (1992) use two values (15% and 30%) as a normal and a large import share, respectively. Here we choose the cross-sectional average of the OECD countries, 22.5% [as in Ravn (1997)], for the benchmark case.

Values for ρ^{-1} of 1–1.5 generally have been used in general equilibrium models of trade but they are believed to be lower bounds for the actual value because estimates of this elasticity parameter are downward biased because of large measurement errors [see Whalley (1985)]. Zimmermann (1994) obtains estimates for OECD countries in the range [0.6 13.5], averaging 5.4. To compare with previous work, we use 1.5 as in Backus et al. (1992) for the benchmark case and perform some sensitivity analyses.

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

TABLE 4. Benchmark parameter values

β	δ	Π	θ	η	e	MS	$1/\rho$	ϕ_g
0.98	0.025	0.5	0.36	0.08	0.8	0.22	1.5	0.2
k	μ_{kn}	γ_{kn}	ρ_a	σ_a^2	ρ_g	σ_g^2	ρ_μ	σ_μ^2
0.02	1.4	1.2	0.835	0.007	0.95	0.005	0.95	0.007

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the presence of declining marginal cost in several industries in the United States. 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 set γ_{kn} equal to 1.2 and perform some sensitivity analyses. Average markup, μ_{kn}, is set equal to 1.4, the mean value across countries of our estimates, but some sensitivity analyses are carried out to check how results vary with μ_{kn}. The overhead cost Φ_h is set such that profits are zero in the steady state.

The share of capital in the production function, α, 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 δ_k, γ_{kn}, α, 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

$$A_{t+1} = C(L)A_t + \epsilon_{t+1}, \qquad \textbf{(16)}$$

where $A_{t+1} = [A_{1t}, A_{2t}, G_{1t}, G_{2t}, \mu_{1t}, \mu_{2t}]'$ and $\epsilon_t \sim N(0, V)$. Therefore, we have to choose parameters for $C(L)$ and V, the variance-covariance matrix. It is recognized widely 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)]. Hence, we follow a different approach [as it is done, for example, by Baxter and Crucini (1993)] and select the parameters to model different scenarios that we may envisage. This also allows us to compare our results with those existing in the literature and isolate the effects of imperfect competition. The benchmark model is a standard symmetric model. The persistence of the technological process is set to 0.835 and the volatility to 0.007 as in Ravn (1997).[4] The cross-country correlation is set to 0.25 as in Backus et al. (1993) and the spillover parameter to 0. With this benchmark parameterization, 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.

The persistence of government spending is set to 0.95 and the standard deviation to 0.005 as in Ravn (1997). As we have seen in Section 2, markups seem to follow a persistent autoregressive process, and therefore we choose a persistence parameter of 0.95 and a standard deviation of 0.007 as in Rotemberg and Woodford (1995). We perform some sensitivity analyses 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 we also experiment with positive (0.25) correlations across countries.

With this parameterization, we analyze several models driven separately by technology and government shocks. In both cases, we compare the cases of perfect competition, imperfect competition with constant markups, and imperfect competition with variable markups. 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 will allow us to check whether markup fluctuations can drive the international business cycle. Therefore, the models that we consider are

- a standard perfectly competitive model with technology shocks (Model T1);
- an imperfectly competitive model with technology 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).

5. SIMULATION RESULTS

5.1. Models with Technology Shocks

Standard model with technology shocks. In Table 5, 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 four aspects of the data that 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 whereas the correlation between exports and output is too small. Third, consumption is more correlated than output across countries whereas in the data the opposite is true. Fourth, 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 focus on these aspects of the models when examining the improvements obtained with alternative specifications.

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

TABLE 5. Simulation results

Model[a]	Data	T1	T2	TM1	TM1C	M1	M1C1	G1	G2	GM1
STD(Y)	[1.03 1.92]	1.47	2.04	2.56	2.61	1.63	1.71	0.10	0.18	1.51
STD(C)/STD(Y)	[0.44 1.17]	0.16	0.17	0.17	0.17	0.15	0.15	1.46	0.90	0.18
STD(N)/STD(Y)	[0.53 1.03]	0.69	0.48	0.79	0.80	1.10	1.10	1.56	1.12	1.12
STD(AP)/STD(Y)	[0.76 1.01]	0.34	0.54	0.44	0.43	0.11	0.10	0.56	0.13	0.13
STD(I)/STD(Y)	[2.21 3.32]	3.13	2.59	3.01	2.95	3.46	3.31	3.28	3.65	4.72
STD(X)/STD(Y)	[2.00 4.76]	1.19	0.98	1.11	1.09	1.25	1.18	1.84	1.35	1.15
STD(M)/STD(Y)	[3.08 7.04]	1.22	1.02	1.12	1.09	1.24	1.17	1.43	1.19	1.18
STD(NX)/STD(Y)	[0.50 1.27]	0.39	0.33	0.37	0.34	0.40	0.33	0.58	0.36	0.35
STD(TT)/STD(Y)	[2.69 7.37]	0.26	0.24	0.21	0.21	0.16	0.13	0.53	0.27	0.21
CORR(C, Y)	[0.42 0.93]	0.67	0.68	0.21	0.13	−0.68	−0.78	−0.99	−0.99	−0.54
CORR(N, Y)	[0.16 0.68]	0.99	0.98	0.91	0.91	1.00	1.00	0.99	0.99	0.99
CORR(AP, Y)	[0.22 0.88]	0.94	0.98	0.65	0.63	−0.87	−0.91	−0.99	−0.99	−0.90
CORR(I, Y)	[0.66 0.93]	0.95	0.95	0.95	0.95	0.97	0.98	0.99	0.99	0.97
CORR(X, Y)	[0.04 0.71]	0.15	0.15	0.14	0.24	0.18	0.40	0.27	0.55	0.28
CORR(M, Y)	[0.18 0.77]	0.96	0.96	0.96	0.96	0.96	0.97	0.85	0.93	0.97
CORR(NX, Y)	[−0.08 −0.61]	−0.56	−0.56	−0.55	−0.51	−0.53	−0.43	−0.27	−0.22	−0.51
CORR(TT, Y)	[−0.41 0.43]	0.41	0.44	0.37	0.35	0.30	0.25	−0.27	−0.22	0.40
CORR(I, S)	[0.10 0.97]	0.96	0.96	0.96	0.96	0.96	0.99	0.61	0.88	0.97
CORR(TT, NX)	[−0.59 0.17]	−0.38	−0.41	−0.34	−0.34	−0.28	−0.28	1.00	1.00	−0.46
CORR(Y, Y*)	[0.26 0.67]	0.25	0.22	0.26	0.34	0.37	0.56	0.86	0.91	0.38
CORR(C, C*)	[−0.14 0.70]	0.61	0.69	0.73	0.76	0.81	0.88	0.77	0.82	0.69
CORR(I, I*)	[0.07 0.77]	−0.23	−0.27	−0.15	−0.02	−0.01	0.23	0.72	0.85	0.07
CORR(X, X*)	[−0.08 0.70]	−0.05	−0.05	−0.08	0.04	−0.06	0.18	−0.43	0.05	0.10
CORR(M, M*)	[0.16 0.91]	−0.16	−0.17	−0.16	−0.05	−0.11	0.14	−0.06	0.36	−0.01
CORR(AP, AP*)	[0.10 0.65]	0.21	0.24	0.23	0.24	0.22	0.56	0.86	0.90	0.22
CORR(N, N*)	[0.10 0.77]	0.26	0.21	0.32	0.47	0.37	0.61	0.86	0.91	0.39
CORR(G, Y)	[−0.02 0.39]							0.86	0.84	0.10
CORR(G, C)	[−0.07 0.40]							−0.09	−0.88	−0.54
CORR(G, I)	[−0.15 0.38]							0.91	0.87	0.08
CORR(G, N)	[−0.18 0.40]							0.86	0.83	0.10
CORR(G, X)	[−0.49 0.29]							−0.22	0.02	0.01
CORR(G, M)	[−0.07 0.38]							0.99	0.98	0.11
CORR(G, NX)	[−0.34 −0.06]							−0.70	−0.70	−0.07
CORR(G, TT)	[−0.02 0.49]							−0.70	−0.69	−0.10
CORR(μ*, Y)	[−0.87 0.12]			−0.59	−0.61	−0.98	−0.98			
CORR(μ*, C)	[−0.63 0.06]			0.39	0.45	0.75	0.81			
CORR(μ*, I)	[−0.61 0.03]			0.01	0.01	0.01	0.01			
CORR(μ*, N)	[−0.35 0.05]			−0.85	−0.86	−0.98	−0.98			
CORR(μ*, X)	[−0.50 0.22]			0.00	−0.16	−0.01	−0.24			
CORR(μ*, M)	[−0.69 −0.10]			−0.67	−0.67	−0.99	−0.99			
CORR(μ*, NX)	[0.06 0.58]			0.46	0.36	0.67	0.58			
CORR(μ*, TT)	[−0.69 0.22]			−0.13	−0.09	−0.37	−0.32			

[a] STD-standard deviation and CORR-correlation coefficient.

level of investment and raises output more than under perfect competition. The dynamics of the model appear in Figure 3. We can see that, as a result of the technology shock, output, investment, and productivity, and thus imports, exports, and the terms of trade, respond more compared to the perfect competition case. 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 foreign investment.

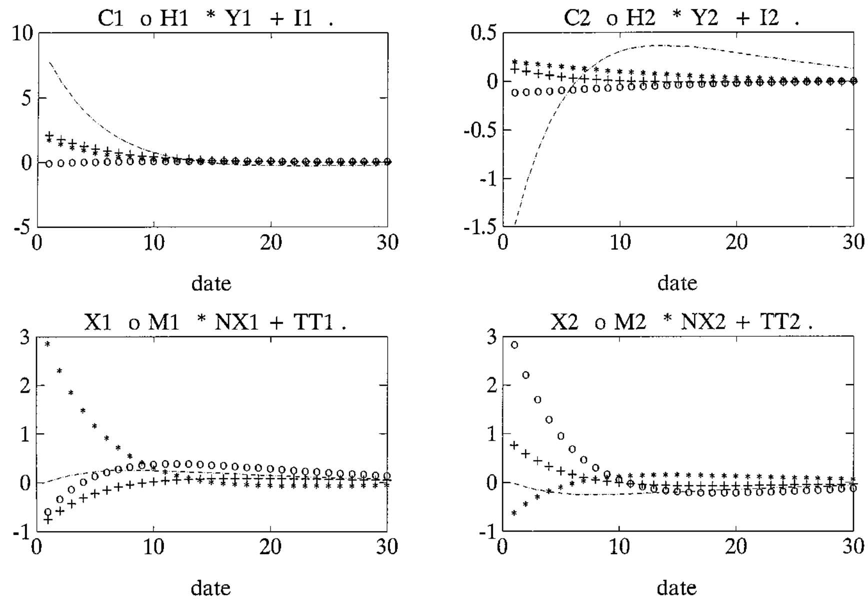

FIGURE 2. Standard model (T1).

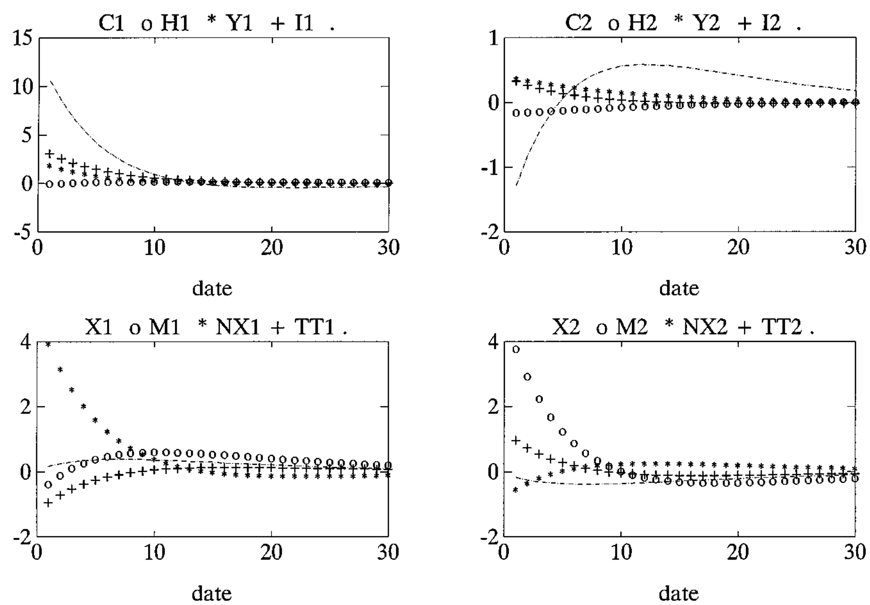

FIGURE 3. Standard model with imperfect competition (T2).

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Therefore, the main effect of imperfect competition is to raise the volatility of all variables, but it raises 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. Hence, our conjecture about the effect of imperfect competition on relative prices was correct, but the increase in variability turns out to be insufficient. 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.

These results are robust to reasonable variations in the imperfect-competition parameters, the scale parameter γ_{kn}, and the average markup μ_{kn} [see Ubide (1996) for a extensive analysis]. Increases in market power just amplify the effects of imperfect competition mentioned above, without any qualitative difference.

Model driven by markup shocks. To understand the dynamics created by variable markups and to gauge their ability to reproduce the main stylized facts of the business cycle, we analyze a model (M1) in which the only source of disturbances is shocks to markups. We can see (Table 5) 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 because 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 positively correlated across countries (column M1C1 in Table 5) the results improve, producing positive cross-country correlations for all variables.

The dynamics of the model are displayed in Figure 4. An increase in markups decreases the rate of return on production factors, and therefore both 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 because of the transfer of resources from investment, decreasing afterward because of the negative wealth effect. The international reallocation of capital goods and the improvement in the terms of trade produce 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 correlations for investment, imports, and exports that are almost positive.

Model with technology shocks and imperfect competition with variable markups. The combination of technology and markup disturbances (Table 5, Model TM1)

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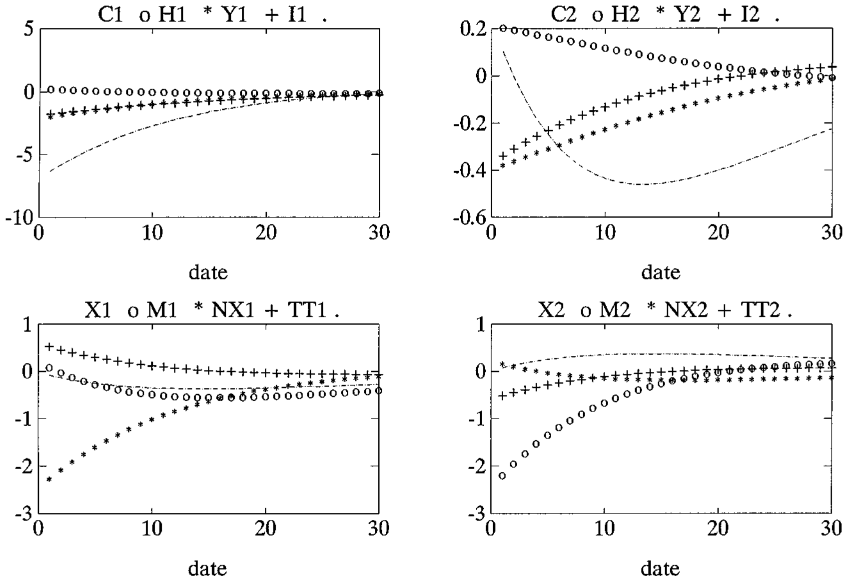

FIGURE 4. Model with only markup shocks (M1).

improves the behavior of the standard model along several lines. The volatility of hours and productivity increases. With respect to the standard model, hours and productivity are less procyclical, whereas exports become positively correlated with output. Regarding cross-correlations, output, consumption, and hours correlations increase, whereas investment, exports, and imports are less negatively correlated across countries. The behavior of the labor-market variables also improves, with hours now being substantially less correlated with 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 that remains too countercyclical. If we allow markups to be positively correlated (Model TM1C), as in the two groups of countries we see in Section 2, the model behaves even better along the same directions.

The main difference in the dynamics of the model (Figure 5) relative to the standard model is that now, after the shock, investment increases very little because of the effect of markups, and therefore output increases only moderately. Hours decrease and wages slightly increase. After the impact, hours, output, and investment decrease, becoming even negative before rising again while returning to the steady state. Thus, the introduction of variable markups reduces the procyclicality of almost all 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.

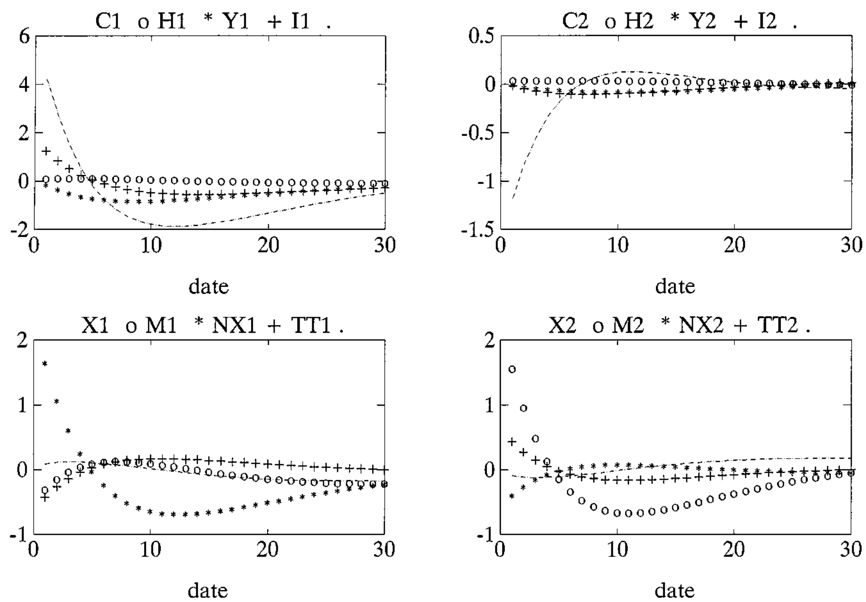

FIGURE 5. Model with variable markups (TM1).

After the impact, investment, hours, and output in the foreign country increase on their way back to the steady state. This implies positive cross-country correlations (or at least less negative) in output, investment, productivity, and hours.

As in preceding cases, the results are robust to variations in the imperfect-competition parameters [see Ubide (1996) for a detailed analysis]. Similarly, the choice of the parameters of the markup process does not significantly affect the results. Variations of the persistence parameter in the range [0.9 1] do not affect volatilities, and affect only slightly some of the correlations of labor-market variables. Variations of the volatility of markups in the range [0.004 0.01] have a more sizable effect, although none of the results is qualitatively affected. As the volatility of markups increases, output and investment volatility increase and therefore the procyclicality of wages and productivity decreases. Again, the relative volatility of both the terms of trade and net exports decreases for the reasons explained earlier. Therefore, our results are valid for a wide range of plausible processes for the markup series. Regarding the sensitivity of the results with respect to the elasticity of substitution in the Armington aggregator, the conclusions are the same 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.

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Hence, the introduction of imperfect competition with variable markups improves the behavior 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 either to raise the relative volatility of foreign trade variables (the price anomaly) nor to obtain output correlations larger than the correspondent consumption correlations (the quantity anomaly). All of 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

Model with government shocks and perfect competition. The right panel of Table 5 shows the first and second moments of a model driven by an aggregate demand shock in the form of an increase in government spending (Model G1). The dynamics of the model are displayed in Figure 6. This model is able to account for some of the facts of international business cycles, such as the relative volatilities of domestic variables and the positive cross-correlation of output, consumption, investment, hours, and wages. Furthermore, as Ubide (1996) shows, with $\phi_g > 0.6$ the model produces consumption correlations that are lower than output correlations. However, there are four important aspects of the data that the model fails to reproduce. First, the variability of output is quite low. Second, the model fails to

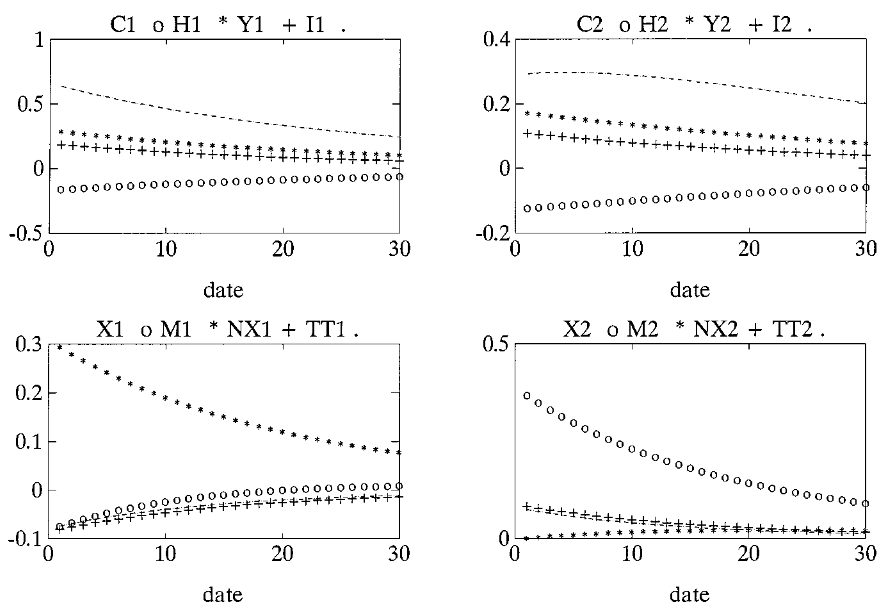

FIGURE 6. Model with government shocks (G1).

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capture the procyclicality of consumption, productivity, wages, and exports. Third, the model produces very low saving-investment correlations. Fourth, imports and exports are negatively correlated across countries.

Ubide (1996) documents the comovements of government spending with domestic and foreign trade variables for a group of OECD countries. The first column of Table 5 contains the range values for the main correlations. As we can see, the matching of the model is not very good, because it produces highly procyclical output, investment, and hours and highly countercyclical consumption. Regarding foreign trade variables, the model is able to replicate the behavior of quantities because it produces net exports that are negatively correlated with government spending due to highly procyclical imports and more neutral exports. However, the model is not able to replicate the behavior of prices because it predicts a highly negative correlation of government spending with the terms of trade, whereas we find a positive one in the data.

The dynamics of this economy are as follows [see Baxter and King (1993) for an analysis in a closed economy and Baxter (1992) for an analysis in a one-good open economy]: An increase in government purchases produces a negative wealth effect in both countries, decreasing households' income. This leads to a decrease in both consumption and leisure that raises labor supply and lowers wages, increasing the return on capital and boosting investment and imports. Because of the perfect-capital-markets assumption, the responses would be identical in a one-good economy, and thus unrealistic. In this two-good economy with imperfect substitution between them, the responses are similar but not identical, and therefore we obtain realistic positive comovements across countries. The only cross-correlations that remain negative are imports and exports because of the different intensity of the investment boom in both countries.

As we said earlier, the model is not able to replicate the behavior 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 leads to a deterioration of the terms of trade. However, there are other factors that are not present in the model and that may affect the terms of trade in the opposite way, such as risk premium or expectation effects, and it seems from the empirical evidence that the final outcome is 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.

Finally, notice that the correlation between saving and investment is quite low. This is so because 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.

Model with government shocks and imperfect competition. The introduction of imperfect competition and increasing returns to scale (Model G2) significantly imroves the behavior of the model. It lowers the volatility of consumption, hours, and productivity and raises that of output and investment, increasing also the

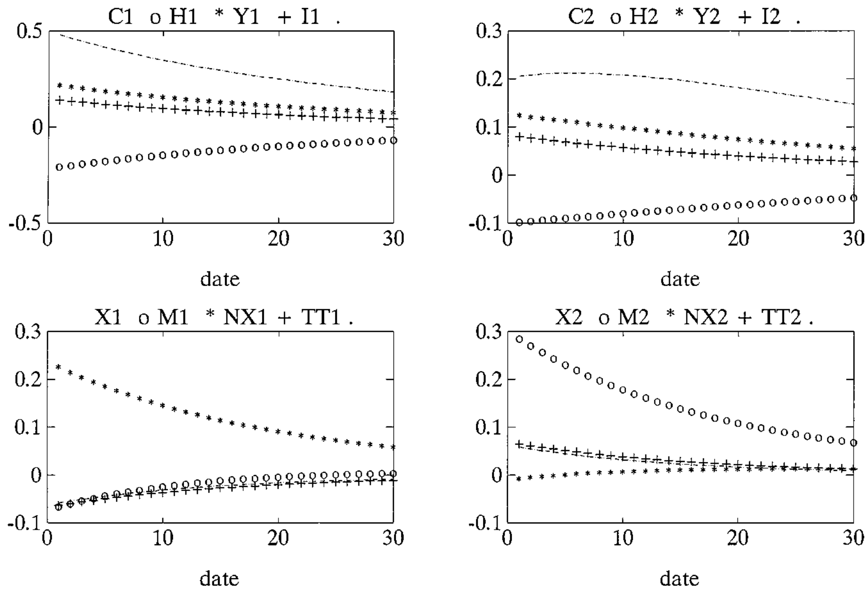

Figure 7. Model with government shocks and imperfect competition (G2).

procyclicality of imports and exports. The saving–investment correlation rises to realistic levels. 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 across countries. However, the model still fails to produce procyclical consumption and productivity, and the volatility of output is still very low. Also, the model fails to produce a positive correlation between government spending and the terms of trade.

The dynamics of this model are displayed in Figure 7. 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 also is translated to the foreign country, where investment, output, and imports respond more than in the preceding case. This creates an increase of exports in the home country (instead of a decrease as was the case under perfect competition) and therefore we obtain positive correlations across countries of output, investment, imports, and exports. 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, 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 causing less deterioration in the balance of trade. Hence, we can obtain high saving–investment correlations in a model with government shocks if we allow for imperfect competition. All of these results are robust to variations in both the imperfect-competition parameters and the foreign trade parameters.

Model with government shocks and imperfect competition with variable markups. If we let markups be variable (Model GM1), we obtain some interesting results. 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 become procyclical. We still obtain positive comovements across countries, with coefficients that now are lower and therefore closer to data. When ϕ_g approaches 1, we also obtain output correlations that are larger than consumption correlations. The matching of government-spending moments is definitely improved. All of 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 that could compete with the standard model driven by technology shocks.

The dynamics of the model (Figure 8) are a blend of the effect of variable markups and government shocks. The effect of the markup shock dominates the dynamics, and therefore, after the impact, the countries are in a 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 because of the negative wealth effect of government spending. All of 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 these results to the imperfect-competition parameters. The results are robust to variations of these parameters, 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.

Finally, we have experimented with different specifications, which included positive cross-country correlations of government shocks, 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.

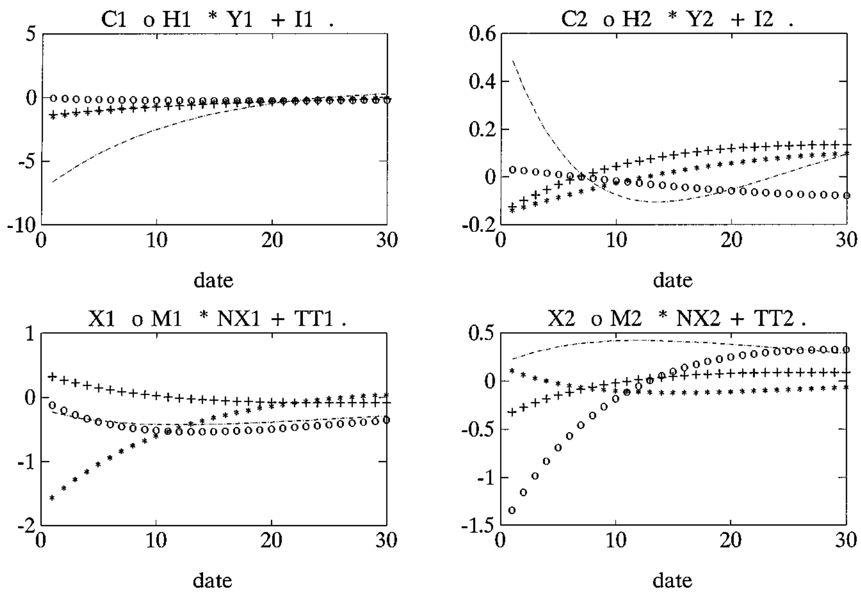

FIGURE 8. Model with government shocks and variable markups (GM1).

6. CONCLUSIONS

We have explored the implications of introducing imperfect competition in a two-country, two-good international real business-cycle model. Our attempt is justified as a necessary extension of these models to incorporate the developments in the new international trade literature, and we have provided new international empirical evidence on markups.

We argue that the introduction of imperfect competition improves the performance models driven by technology and government spending shocks along several lines. We have shown 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 also is able to replicate the main stylized facts of markups. However, the model is not able either to raise the relative volatility of foreign trade variables or to obtain output correlations larger than the correspondent consumption correlations. We also have shown 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.

In models with government spending shocks, the introduction of imperfect competition improves significantly the behavior of the model. It produces realistic volatilities and domestic comovements, high saving–investment correlations and positive comovements across countries. We show that a model driven by government spending shocks with variable markups can explain the pattern of international business cycles at least as well as a model driven by technology shocks. In particular, it can produce a sensible pattern of cross-country correlations without having to resort to correlated shocks across countries, although it needs high values of markups to produce procyclical consumption. However, despite the relative success of our exercise, the price anomaly remains unsolved.

We conclude that imperfect competition is a crucial feature to be included in models of international business cycles and, although we have modeled 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 by Rotemberg and Woodford (1995) could be adapted to the open-economy environment.

NOTES

1. This is implemented by imposing $\text{Cov}[x_t(\mu^*), \varepsilon_{gt}] = 0$, where x_t is the measure of technical progress assumed to be stationary around a linear trend and ε_{gt} is the residual of fitting an AR(1) process with $\rho_g = 0.95$ to the detrended government expenditure series.

2. This is justified by the fact that, in the United States, about two thirds of the volatility of total hours worked appears to be due to movements into and out of the labor force, whereas 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.

3. In doing so, we ensure that entry plays a small role in the short-term dynamics of the model and does not generate unrealistic large fluctuations.

4. It is widely known that the Solow residual does not accurately represent the true technology shocks under imperfect competition [see Deveraux et al. (1996) for an analysis]. However, because we are not interested in evaluating the amount of output variability that is accounted for by technology shocks, we keep the standard Solow residual process to isolate the effects of different dimensions of increasing returns on international facts.

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