Output dynamics and persistence in open economies

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Abstract

Cogley and Nason [1995] underline that the dynamics of US output growth is characterized by positive autocorrelations over short term horizons. We show that the persistence properties of US output are country-specific. OECD data actually supports a negative relationship between output persistence and openness: open economies tend to display lower output persistence than more closed exemplified by the US.

In our view, this stylized fact is related to adjustment lags in factor accumulation as a vector of persistence. Factor accumulation is faster when firms import inputs and can run into debt vis-à-vis the foreign countries. In closed economies, firms have to delay investment until resources become available. If goods produced in different economies are close substitutes, a positive productivity shock in one economy gives rise to large investment inflows, which speeds up factor accumulation and reduces the persistence of output.

We build a two-country model with adjustment costs supplemented with variable factor utilization. It successfully predicts the inverse relationship between persistence and openness observed in OECD countries.

1 Introduction

Attention in Business cycle analysis has shifted from the amplification of aggregate shocks to the study of their propagation over time, following the contributions of Cogley and Nason [1995] and Rotemberg and Woodford [1996]. On US data, the richness of the dynamics of output is jointly witnessed by the positive autocorrelations of output growth over short horizons,

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the peak in the power spectrum of output growth at business cycle frequencies and the hump–shaped response of the impulse response functions of output. Cogley and Nason [1995] show that standard RBC models fundamentally lack a strong enough propagation mechanism to account for these dynamic properties of US output.

In this paper, we argue empirically and theoretically that the persistence properties of US output are country–specific. Regarding the observed autocorrelation function of output growth among OECD countries, the first–order autocorrelation ranges from .8 (Spain) to -.6 (Norway), the US figure being .4. More specifically, we find evidence of a negative correlation between persistence of output and the degree of openness of an economy, measured as the share of international trade in output.

This paper first investigates empirically the relation between output persistence and the degree of openness of OECD countries. We find strong support in favor of a decreasing relationship: widely open economies (such as Switzerland or the Netherlands) tend to have lower persistence in output than relatively closed economies, exemplified by the United States. This finding is robust to the characterization of output persistence. Our measures include the first–order autocorrelation of output growth and, in the frequency domain, the spectrum area which corresponds to business–cycle frequencies.

In a second step we look for theoretical explanations of these international pieces of evidence. The existing literature on output persistence highlights the role of two distinct mechanisms, factor accumulation and costly reallocation. On one side, the multi–sector models of Benhabib, Perli and Sakellaris [1997], Perli [1998] and Huang and Liu [2001] show how sectorial reallocations of productive factors in response to productivity shock is long–lasting, and propagates the effects of shocks over time. Gradual reallocation across sectors seems *a priori* independent of economic openness — except if reallocation were easier between countries than between sectors of the domestic economy.

On the other side, Burnside and Eichenbaum [1996] and Perli and Sakellaris [1998] study the effects of the gradual accumulation of productive factors on output. In (some of) these papers, an increase in output today enables to accumulate factors at a greater pace, which may in turn lead to another rise in output next period. Whether output effectively displays hump–shaped patterns and persistence actually depends on the speed of accumulation and of the behaviors of other production factors (typically, labor input decreases after a positive productivity shock and directly drives output to the steady–state).

Contrarily to the multi–sector reallocation approach, we argue that factor accumulation is likely to be affected in an open economy. Factor accumulation is in fact easier and quicker when agents have access to imports

than when they don't, and when agents can run into debt *vis-à-vis* foreign countries. If the goods produced in the different economies are close substitutes, an increase in productivity specific to one economy gives rise to large investment inflows in this economy (Baxter [1995] or Baxter and Farr [2001]). In this case, factor accumulation is early and short–lasting which breaks the aforementioned mechanism.

We formulate a two–country general equilibrium model in which we control for the openness of the economies. Accumulation of physical capital is the vector of persistence in the closed–economy version of this model. It has been routinely emphasized that capital accumulation did not provide a strong enough propagation mechanism to reproduce the observed output dynamics (see Cogley and Nason [1995]). Capital accumulation is supplemented here with variable capital utilization, modelled in the lines of Kydland and Prescott [1988] or Bils and Cho [1994]. After a shock, variations in capital utilization enhance the response of output, increase savings and finally yields a surge in investment which has sizeable effects on the capital stock. As argued elsewhere (Collard and Dupaigne [1999]), a model combining these two features can statistically match the autocorrelation function of output growth computed on US data.

In a two–country framework, we show that the first order–autocorrelation of the output growth monotonically decreases with the openness of the economy, measured as the share of imports in output . In an open economy, the relationship between investment and output is less stringent than in a closed one. Technically speaking, the resource constraint is replaced by a debt accumulation one (a solvency constraint). This means than during good times, domestic firms can instantaneously invest a very high share of national output — the price to pay being an increase in foreign debt. On the contrary, the more closed the economy, the longer firms have to wait until resources become available to invest.

Our discussion is organized as follows. Section 2 analyzes the pattern of output growth dynamics in OECD countries. Section 3 presents the building blocks of our model. After analyzing the aggregate dynamics in section 4, quantitative predictions of our model are discussed in section 5. Section 6 concludes.

2 International evidences on output dynamics

Cogley and Nason [1995] argue that US output dynamics is characterized by a significant degree of persistence. They base this claim on two quantitative criteria, the autocorrelation function of output growth and the share of the variance of output growth due to the business cycle, and a qualitative one, the existence of a hump–shaped impulse response function of output to a transitory shock.

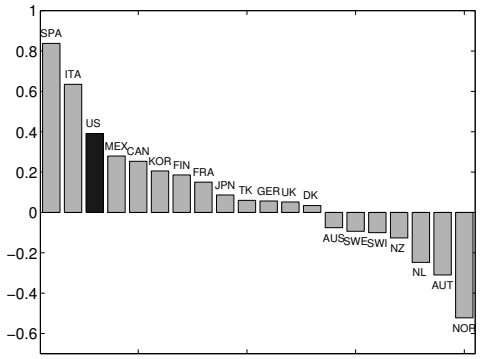
Our intuition is that Cogley and Nason [1995]'s stylized fact is not robust if we examine economies that are more open than the US. This section aims at gauging the empirical relevance of this intuition by examining the relationship between openness and persistence captured by the sample autocorrelation (section 2.1) and the spectral decomposition (section 2.2) of output growth. We also investigate whether other variables are systematically correlated with the degree of persistence (section 2.3).

2.1 Autocorrelation of output growth

In order to capture output persistence, we first compute the first–order autocorrelation of real GDP growth, the latter being defined as the sum of private consumption, investment, government spending and net exports. Quarterly times series, spanning 1970:1-1999:4, are available on OECD Business Sector Database.

Figure 1 confirms the aforementioned results by Cogley and Nason [1995]: US output is positively autocorrelated at one lag. Spain and Italy appear even less persistent, with first–order autocorrelation respectively above .8 and .6. On the other side, the Netherlands, Austria and Norway are the three countries with the lowest autocorrelation.

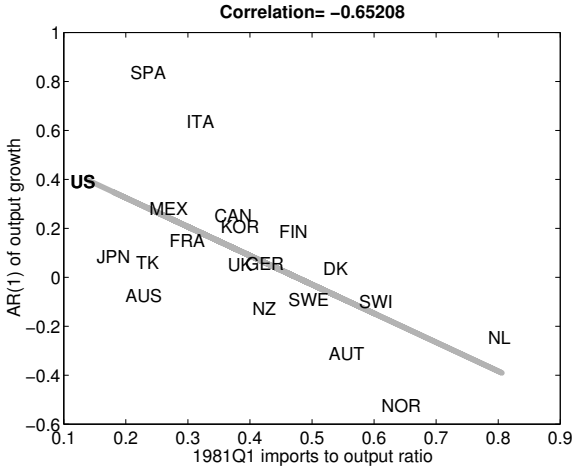
Figure 1: First–order autocorrelation of output growth



To explain the large dispersion of output growth autocorrelation across countries displayed in figure 1, we plot the first–order autocorrelation of output growth versus the degree of openness for the 20 countries of our sample. Throughout our analysis, the measure of the degree of openness used is the ratio of imports to output.

Figure 2 highlights the negative relationship between openness and persistence, which is apparent in the least–square fit of the scattered data (grey line). The cross-section data does exhibit a negative correlation of -0.65. Output dynamics is less persistent in more open countries while more closed economies display higher sample autocorrelation.

Figure 2: Output persistence and openness: AR(1)



2.2 Spectral decomposition

The economic significance of the autocorrelation function becomes transparent when it is transformed into frequency domain. The spectrum for output growth is estimated by smoothing the periodogram using a Bartlett window. The spectrum decomposes the variance of output growth by frequency. A peak in the spectrum indicates that the corresponding periodic components have greater amplitude than other components and therefore contribute a greater portion of the variance.

Figure 3: Spectral decomposition

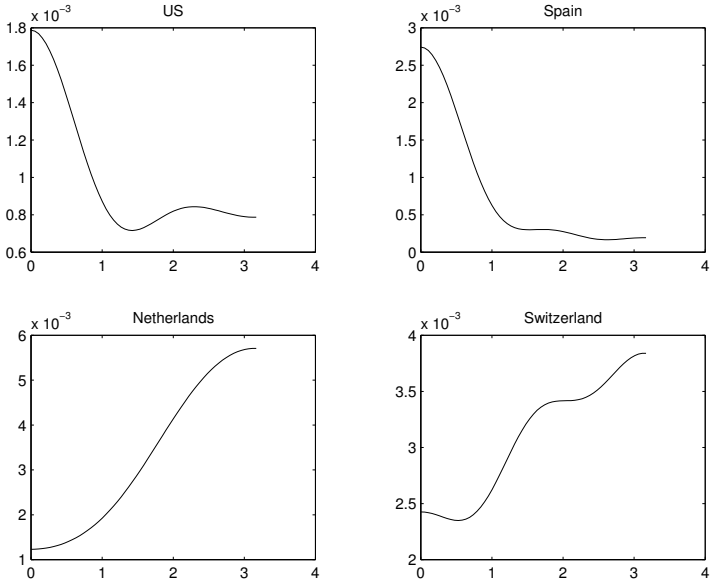


Figure 3 displays the spectrum for output growth in two closed economies (the US and Spain) and in two open economies (Norway and the Netherlands). The horizontal axis reports the frequency domain ω comprised between 0 and π. US and Spanish output dynamics exhibit a peak at low frequency while a large fraction of the variance of output growth rate in Norway and the Netherland is explained by cycles at higher frequencies.

In order to check the relevance of this intuition over the 20 countries of our sample, we compute the fraction of output growth occurring at business cycle frequencies (*i.e.* between 6 and 32 quarters). The result of this computation is summarized on figure 4. The rankings of countries in terms of persistence implied by our two measures are very close: Spain, Italy and the United States being the most persistent economies and the Netherlands, Austria and Norway the least persistent.

Figure 4: Share of the variance of output growth imputable to business–cycle frequencies

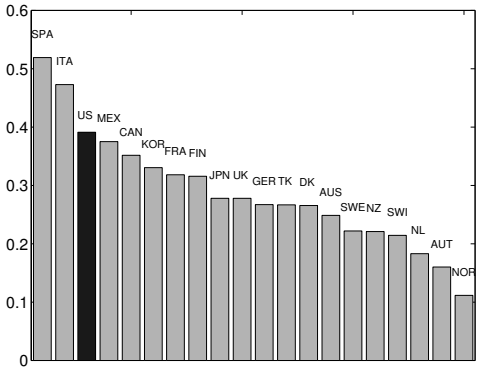
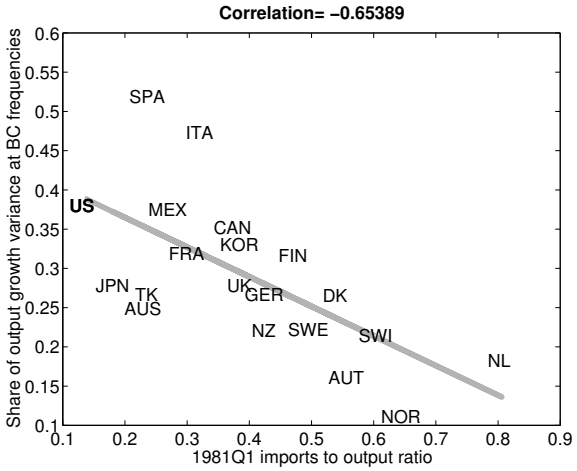


Figure 5: Output persistence and openness: frequency domain measure



As with the first–order autocorrelation of output growth, we link in figure 5 the proportion of output growth occurring at the business cycle frequency to the degree of openness. The scattered plot could be fitted with a downward sloping curve of -0.63. In more closed economies, a large proportion of the variance of output growth occurs at business cycle frequencies while this fraction is lower in more open economies.

Finally, we perform OLS regressions. The t-stats, displayed between brackets in table 1, confirm the statistical significance of the relationship between openness and persistence

Table 1: Openness and output persistence: OLS regressions

	constant	imports to output ratio
AR(1)	.5606	**-1.1799**
		[-3.7491]
% of variance	.4404	**-.3775**
at BC frequencies		[-3.7673]

2.3 Alternative explanations of the differences in output persistence

On average over of sample of OECD countries, open countries tend to display less persistence than closed ones. Before we build a general equilibrium model trying to reproduce this feature, we check that this observed relationship is not due to a third, unobserved/unaccounted for, factor. Obvious examples of such third variables are the size of the economy or the average growth rate, which are both negatively correlated with the degree of openness (see table 2).

Table 2: Correlations between the openness, the size and the average growth rate

	openness	size	growth rate
openness	1	-.6953	-.3309
size	-.6953	1	.0801
growth rate	-.3309	.0801	1

Figure 7, in appendix, plots our two indexes of persistence versus the initial size of the economy, measured by the logarithm of 1981Q1 GDP.[1] Not surprisingly, the large economies of our sample (which tend to be less

[1]The (working age) population or the surface area of a country provide alternative measures of the size of an economy. However, both factors remain to some extent endogenous (see Alesina and Spolaore [1997]).

open), display a lower degree of persistence than relatively small ones. The degree of persistence does not appear to be systematically related to the average growth rate of output (figure 8).

Table 3 confirms these insights: the coefficient of the average growth rate is never significantly different from 0, the coefficient of the initial size does only differ significantly from zero for the time–series domain index.

Table 3: Size and average growth rate: OLS regressions

	constant	Log of 1981Q1 GDP
AR(1)	-1.7952	**.1461**
		[2.7227]
% of variance	-.3052	-.0461
at BC frequencies		[.8583]
	constant	Average growth rate of output
AR(1)	-.1948	11.7014
		[.5503]
% of variance	.1922	4.0931
at BC frequencies		[.6218]

Other variables could provide a better explanation of the heterogeneity in persistence observed in the data. We also check in figures 9 and 10 whether the degree of output persistence is, in our sample of OECD countries, systematically related to the capital intensity and to the volatility of output growth.

Figure 9 shows that economies where the private capital-to-output ratio is higher than average tend to display less persistence than average – which somehow means that capital is not a crucial vector of output persistence. Figure 10 exhibits a negative correlation between output persistence and the standard error of output growth. However, as table 4 makes clear, the large estimated negative coefficient of the volatility of output growth is partly due to an outlier. As a matter of fact, the standard error of output growth in Norway, which is the less persistent country in our sample, is 50% larger than the second largest, Turkey.

To summarize these empirical findings, we have exhibited significant comovements between our two measures of persistence and three different factors: the degree of openness, the size of the economy and the variance of output growth. In table 5, we now investigate whether the relationship between persistence and openness still holds when we control for the two other factors.

When we measure persistence with the first–order autocorrelation of out-

Table 4: Capital intensity and variance of output growth rate: OLS regressions

	constant	K/Y
AR(1)	.3727	-.1617
		[-1.0058]
% of variance	.3816	-.0530
at BC frequencies		[-1.0481]
	constant	Std dev. of output growth
AR(1)	.3514	**-17.2605**
		[-2.5178]
AR(1)	.2864	-12.0955
excl. Norway		[-1.1611]
% of variance	.3690	**-5.2331**
at BC frequencies		[-2.3547]

put growth and control for the openness of the economy, the negative effect of the variance of output growth only holds on the sample that includes Norway, the outlier. When we measure persistence as the share of the variance of output due to business cycle frequency, the estimated coefficient of the variance of output growth does not differ statistically from zero.

For both measures of persistence, the size of the economy does not have any explanatory power in a regression that includes the degree of openness.

We therefore conclude that the relationship between persistence and openness is the only one that holds regardless of the other factors included. In the next section, we use a two countries general equilibrium model to investigate the impact of exogenous modifications of the degree of openness on the persistence of output.

3 An open economy model with variable factor utilization

In the lines of Backus, Kehoe and Kydland [1994], we build a model economy including two countries, respectively labelled as 1 and 2 (domestic and foreign). In each country, an intermediate good and a final good are produced.

In the intermediate good sector, country 1 fully specializes in the production of an intermediate good a and country 2 specializes in a different intermediate good b. On the contrary, firms of both countries produce the same final good, using both intermediate goods a and b as inputs.

Table 5: Multivariate regressions

	cstant	variance	size	openness	R^2
AR(1)	.6578	-14.0332 [-1.9345]	.0011 [.0165]	**-.9475** [-2.2391]	.5554
AR(1)	.6737	**-14.0762** [-2.0793]		**-.9518** [-2.8479]	.5554
AR(1) excl. Norway	.6880	-12.4885 [-1.5303]		**-1.0207** [-3.3674]	.4292
AR(1)	-.0783		.0455 [.6902]	**-1.0222** [-2.1960]	.4575
	cstant	variance	size	openness	R^2
% of variance at BC frequencies	1.2063	-17.5030 [-1.8117]	-.0496 [-.8133]	**-1.0582** [-2.8034]	.5675
% of variance at BC frequencies	.4485	-13.6008 [-1.5912]		**-.8955** [-2.7448]	.5507
% of variance at BC frequencies	.3036		.0053 [.0911]	**-1.1496** [-2.8136]	.4840

3.1 The final good sector

In country i, a large number of competitive firms combine intermediate goods $a_{i,t}$ and $b_{i,t}$ to produce $G_i(a_{i,t}, b_{i,t})$ units of the unique final good through the following constant–returns–to–scale CES technology:[2]

$$\begin{cases} G_1(a_{1,t}, b_{1,t}) &= \left[(1-\gamma_1)^{\frac{1}{\theta}} (a_{1,t})^{\frac{\theta-1}{\theta}} + \gamma_1^{\frac{1}{\theta}} (b_{1,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \\ G_2(a_{2,t}, b_{2,t}) &= \left[(1-\gamma_2)^{\frac{1}{\theta}} (a_{2,t})^{\frac{\theta-1}{\theta}} + \gamma_2^{\frac{1}{\theta}} (b_{2,t})^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \end{cases} \tag{1}$$

with θ the elasticity of substitution between $a_{i,t}$ and $b_{i,t}$, and $1-\gamma_i$ the home–bias in the production of final goods which are consumed and accumulated.

Final–goods–producing firms solve the following simple optimization problem

$$\max_{\{a_{i,t}, b_{i,t}\}} G_i(a_{i,t}, b_{i,t}) - q^a_{i,t} a_{i,t} - q^b_{i,t} b_{i,t} \qquad i = 1, 2$$

with $q^a_{i,t}$ and $q^b_{i,t}$ the prices of goods a and b in country i at date t in terms of the final good.

3.2 Firms in the intermediate goods sector

As in Baxter and Farr [2001], this baseline two–country model is extended for variable factor utilization, expressed here both in terms of the workweek of labor and the workweek of capital.

3.2.1 The workweek of labor

Following Kydland and Prescott [1991], Cho and Cooley [1994] or Andolfato [1996], we consider simultaneous fluctuations in the level of employment $N_{i,t}$ — the extensive margin — and individual hours $H_{i,t}$ — the intensive margin. The level of employment is assumed to be a quasi–fixed input, through a structure of adjustment costs that we will describe later. Considering these two margins, flows of labor productive services equal total hours worked, $H_{i,t}N_{i,t}$.

3.2.2 The workweek of capital

Capital utilization is modelled in a similar way to labor utilization. Flows of capital services can be adjusted instantaneously through variations in the capital operating time. As in Kydland and Prescott [1988] and Bils and Cho [1994], the workweek of capital increases with individual hours and

[2] The exposition of this framework closely follows Heathcote and Perri [2002].

employment: capital is used longer when workers work long hours or when workers are hired to operate a new shift.[3]

We denote $\mathcal{K}_{i,t}$ the productive flows of capital: $\mathcal{K}_{i,t} = N_{i,t}\, H_{i,t} \cdot K_{i,t}$.

3.2.3 Technology

Intermediate–goods–producing profit–maximizing firms have access to a Cobb-Douglas technology with constant returns to scale with respect to the productive flows of labor $N_{i,t}H_{i,t}$ and capital $\mathcal{K}_{i,t}$:

$$Y_{i,t} = (A_{i,t}\, N_{i,t}\, H_{i,t})^{\alpha}\, \mathcal{K}_{i,t}^{1-\alpha} \qquad i = 1, 2 \tag{2}$$

In equation (2), $A_{i,t}$ denotes a specific Harrod–neutral technological progress, which follows the stochastic process

$$A_{i,t} = A_{i,t-1}\, \overline{a}\, \exp(\varepsilon_{i,t}) \qquad i = 1, 2$$

where $\overline{a} > 1$ denotes the unconditional mean of the rate of growth of technology, and $\varepsilon_{i,t}$ is a centered gaussian white noise process with standard deviation σ.

3.3 Households

Both economies are inhabited by the same measure, normalized to one, of identical infinitely–lived households, which consume or accumulate the final good and supply labor to the intermediate goods producing firms.

3.3.1 Capital accumulation

Households in both countries accumulate the final good subject and rent it to the firms which produce the intermediate goods. Accumulation is subject to a common depreciation rate $0 \leq \delta \leq 1$ and to quadratic adjustment costs on the capital to employment ratio which cancel out in steady–state:

$$K_{i,t+1} = (1 - \delta)\, K_{i,t} + I_{i,t} - X_{i,t} \qquad i = 1, 2 \tag{3}$$

with $X_{i,t} = \frac{\varphi}{2} \left[\frac{K_{i,t+1}/N_{i,t+1}}{K_{i,t}/N_{i,t}} - \overline{a} \right]^2 K_{i,t} \qquad i = 1, 2.$

3.3.2 Asset accumulation

Financial markets are complete. For each future state of nature s_{t+1}, there is a contingent claim that promises the payment of one unit of good a in this state of nature. We note $B_i\left(s_{t+1}\right)$ the amount of this contingent claim

[3] In contrast to the depreciation–in–use setup, these papers emphasize the labor costs associated with greater capital utilization.

purchased by households of country i and $\chi\left(s_{t+1}\right)$ its price relative to the good a. The asset accumulation equation in countries i writes:

$$q_{i,t}^{a}\int\chi\left(s_{t+1}\right)B_{i}\left(s_{t+1}\right)ds_{t+1}+C_{i,t}+I_{i,t}+X_{i,t}\leq q_{i,t}^{a}\,B_{i}(s_{t})+G_{i}\left(a_{i,t},b_{i,t}\right)\quad(4)$$

3.3.3 Labor supply and consumption decisions

When working, each household of country i chooses the amount of hours devoted to productive activities $H_{i,t}$, but incurs a fixed cost of ζ hours of leisure to go to work. The temporal utility function of an individual working $H_{i,t}$ hours is given by

$$\ln(\tilde{C}_{i,t})+\omega\ln(T-\zeta-H_{i,t})\qquad i=1,2$$

where T is the total time endowment. When not working, the temporal utility of an individual is simply given by

$$\ln(\tilde{C}_{i,t})+\omega\ln(T)\qquad i=1,2$$

Households and firms trade employment lotteries. As usual, the expected utility of an household from country i becomes

$$U\left(\tilde{C}_{i,t},H_{i,t}\right)=\ln(\tilde{C}_{i,t})+\omega N_{i,t}\ln\left(\frac{T-\xi-H_{i,t}}{T}\right)\qquad i=1,2$$

The decentralized equilibrium in country 1 solves the following Bellman equation:

$$V_{1,t}=\max\left\{\ln\tilde{c}_{1,t}+\omega N_{1,t}\ln\frac{T-\zeta-H_{1,t}}{T}+\beta\int\chi(s_{t+1})V_{1,t+1}ds_{t+1}\right\}$$

subject to

$$\begin{aligned}q_{1,t}^{a}\int\chi\left(s_{t+1}\right)B_{1}\left(s_{t+1}\right)ds_{t+1}+C_{1,t}+I_{1,t}+X_{1,t} &\leq q_{1,t}^{a}\,B_{1}(s_{t})+G_{1}\left(a_{1,t},b_{1,t}\right)\\ k_{1,t+1} &\leq (1-\delta)\frac{k_{1,t}}{a_{t}}+i_{i,t}\\ N_{1,t}+1 &\leq Z_{1,t}N_{1,t}\end{aligned}$$

where small letter refer to intensive variables, deflated by total factor productivity $A_{i,t}$, and $a_{i,t}=\frac{A_{i,t}}{A_{i,t-1}}$. The counterpart Bellman equation of country 2 can be inferred by symmetry.

3.4 Market–clearing conditions

Markets of goods a and b clear if

$$\begin{cases} a_{1,t} + a_{2,t} &= Y_{1,t} \\ b_{1,t} + b_{2,t} &= Y_{2,t} \end{cases}$$

Market clearing for final goods requires that

$$\begin{cases} G_1(a_{1,t}, b_{1,t}) &= C_{1,t} + I_{1,t} + X_{1,t} \\ G_2(a_{2,t}, b_{2,t}) &= C_{2,t} + I_{2,t} + X_{2,t} \end{cases}$$

3.5 Calibration

We calibrate the structural parameters of our two–country model economy. The calibration is symmetric and refers to US post–war data. The retained values are summarized in tables 6 and **??**.

Table 6: Values of the deep parameters

β	T	ζ	θ	α	δ	$\bar{a}$	σ_a	φ
.99	1369	60	1.5	.58	.025	1.004	.0056	$8.75 \cdot 10^{-4}$

The total time endowment T and the fixed cost of working ζ were fixed at 1,369 and 60 hours per quarters following Burnside, Eichenbaum and Rebelo [1993]. β was set equal to 0.99. The elasticity of substitution between the two goods is set to 1.5, according to Backus et al. [1994]. The elasticity of output to the labor input α, the depreciation rate of physical capital δ and the average growth rate of total factor productivity $\bar{\gamma}$ are respectively set equal to 0.58, 0.025 and 1.004, by referring to earlier work (see e.g. King, Plosser and Rebelo [1988] or Cooley and Prescott [1995] among others).

The steady–state employment rate, N, is set equal to 58%, which correspond to their average over the sample we consider.

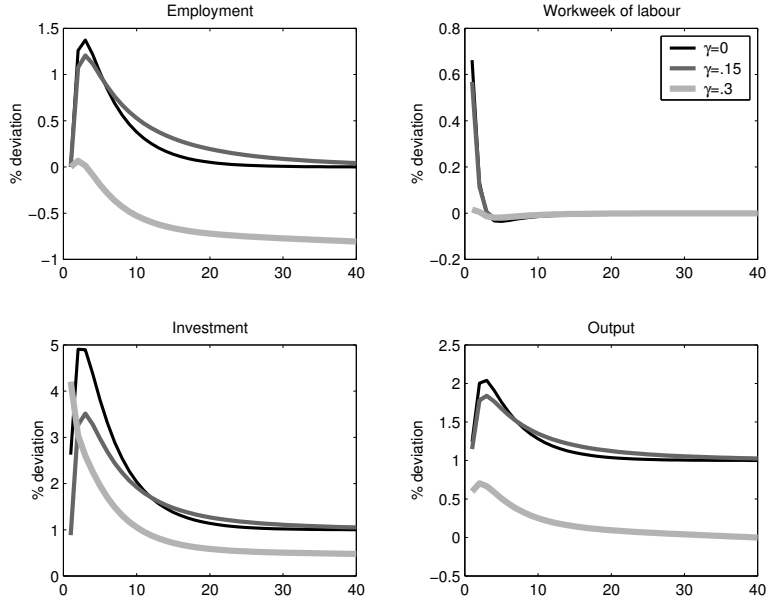
The standard error of the technological shock, $\sigma_a = .0056$ is set referring to the estimations performed in Collard and Dupaigne [1999]. Finally, the size of the adjustment cost, $\varphi = 8.75 \cdot 10^{-4}$, is chosen such that the first–order autocorrelation of output growth matches the US observed one in the closed–economy version of the model.

4 Aggregate Dynamics

We now highlight some qualitative properties of the two–country model economy described in the previous section. To analyze the impact of the degree of openness on the persistence of output, we use an equilibrium relation implying that the share of imported goods in domestic expenditures equals γ_1, which quantifies the 'taste' for goods produced in the foreign country.

We compare the shapes of the impulse response functions to a permanent aggregate technology shock for 3 of this exogenous parameter: $\gamma_1 = 0$, 015 and 0.3.

Figure 6: Impulse response functions: technological shock



4.1 $\gamma_1 = 0$: The 'closed–economy' case

The controlled experiment $\gamma_1 = 0$ means that goods produced in foreign firms are not consumed nor accumulated by domestic households. It however differs from a pure closed–economy since households of both countries trade contingent claims: the domestic economy may borrow (or lend) after a country–specific shock occurs.

Without any international trade, the propagation over time of a permanent productivity shock goes like this. The exogenous rise in productivity shifts factor demands up. Physical capital and employment being predetermined, only the workweek margin adjusts: workers and equipment work longer hours. The increase in output is nearly twice as large as the direct effect of the productivity shock[4] (lower right panel, black line). Employment and investment begin to adjust in the second period, while the workweek of labor decreases back to its steady state reflecting preferences over employment and hours. The employment level does not decrease after the second period, because the adjustment cost structure provides incentive to smooth the capital to employment ratio. The employment path therefore follows

[4]This direct effect is α% given the way the productivity term enters the production function.

the gradual accumulation of capital. Hence, the peak response of capital is delayed until the third period. The subsequent increase in output is roughly equal to one third of the initial response. This slow adjustment pattern characterizes the persistence of output.

4.2 $\gamma_1 = 0.15$

The second experiment describes an economy with a medium degree of openness. The propagation over time of the technological shock looks qualitatively the same as our closed–economy benchmark. Quantitatively however, the peak responses of the workweek and employment are lower. As a consequence, output remains lower than the benchmark case in the short run. his is also the case for investment.

4.3 $\gamma_1 = 0.3$

The share of imported goods reaches 30% in this model economy. Domestic firms willing to invest after the permanent productivity shock can import foreign goods, and domestic households can borrow from foreign households. These two effects result in an instantaneous surge of investment, which exceeds the peak response in the closed–economy case by 50%. This investment burst is debt–financed. On impact, individual hours decrease; so does gradually employment, reflecting the large wealth effect of this permanent exogenous increase in productivity. Overall, domestic output reaches monotonically its new steady–state from below, with monotonically decreasing growth rates. The first–order autocorrelation of output growth is therefore expected to be (slightly) negative for this value of the parameter γ_1.

5 Openness and persistence

In this section, we evaluate the predictions of our theoretical model for different values of the home–bias in the production of the final good. We run two distinct experiment. In the first one, labelled 'asymmetric', we vary the value of the home–bias of country 1, γ_1, keeping γ_2 constant and equal to .091, which corresponds to the average share of imports to GDP in the US. In the second experiment, labelled 'symmetric', both parameter values change simultaneously.

Table 7 summarizes the output growth autocorrelation as a function of openness. The data displays an inverse relationship between the degree of openness and output persistence: in closed economies, exemplified by the US, output dynamics is more sluggish than in open economies such as Sweden. Table 7 shows that the model captures this essential feature. When the import-to-output ratio is calibrated to that of the US (9.1%), variable

capital utilization generates a more persistent output dynamics than when the import share is larger.

Table 7: Economic openness and persistence: AR(1)

Openness (γ_1)	.35	.3	.25	.2	.15	.1
asymmetric countries ($\gamma_2 = $ cstant)	.2461	.3019	.3559	.3927	.4135	.4180
symmetric countries ($\gamma_2 = \gamma_1$)	N/A	.3385	.3981	.4393	.4196	.4167

Table 8 reports the fraction of output growth occurring at business cycle frequencies (between 8 and 28 quarters) as observed in data and as simulated by the model. The data confirms the negative relationship between openness and persistence: a large proportion of the variance of output growth occurs at business cycle frequencies while this fraction is lower in more open economies. Table 8 confirms that the two-country model with adjustment costs on factor accumulation is able to capture this stylized fact.

Table 8: Economic openness and persistence: frequency domain

Openness (γ_1)	.35	.3	.25	.2	.15	.1
asymmetric countries ($\gamma_2 = $ cstant)	.3647	.3842	.4081	.4257	.4369	.4417
symmetric countries ($\gamma_2 = \gamma_1$)	.3606	.4114	.4273	.4499	.4425	.4416

6 Conclusion

Cogley and Nason [1995] argue that business cycle models are unable to mimic US output growth persistence. They accordingly suggest that RBC literature should devote further attention to modelling internal sources of propagation. We qualify this statement by showing that, in OECD countries, output dynamics is closely related to openness. The more open the economy, the less persistent the output growth.

In our view, this inverse relationship between output sluggishness and openness stems from capital accumulation and variable factor utilization. In an open economy, the relationship between investment and output is less stringent than in a closed one. During good times, domestic firms can instantaneously invest a very high share of national output — the price to pay being an increase in foreign debt. On the contrary, the more closed the economy, the longer firms have to wait until resources become available to invest. In addition, factor accumulation is in fact easier and quicker when

agents have access to imports than when they don't, and when agents can run into debt *vis-à-vis* foreign countries. If the goods produced in the different economies are close substitutes, an increase in productivity specific to one economy gives rise to large investment inflows in this economy. In this case, factor accumulation is early and short–lasting. We find that these mechanisms do capture the negative relationship between openness and persistence.

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Figure 7: Output persistence and size

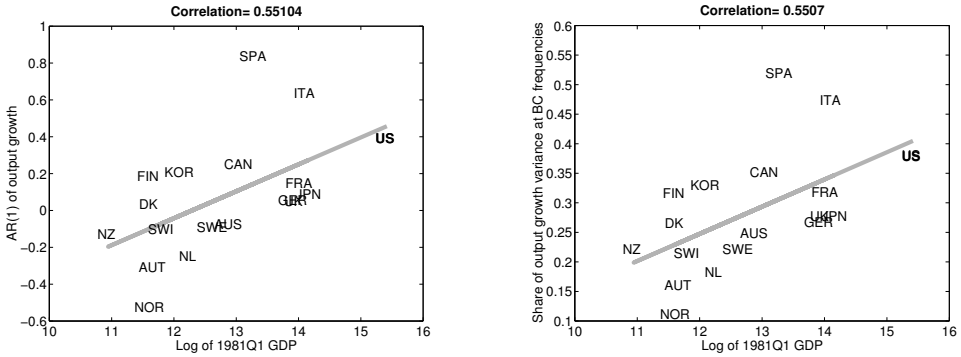

Figure 8: Output persistence and average growth rate

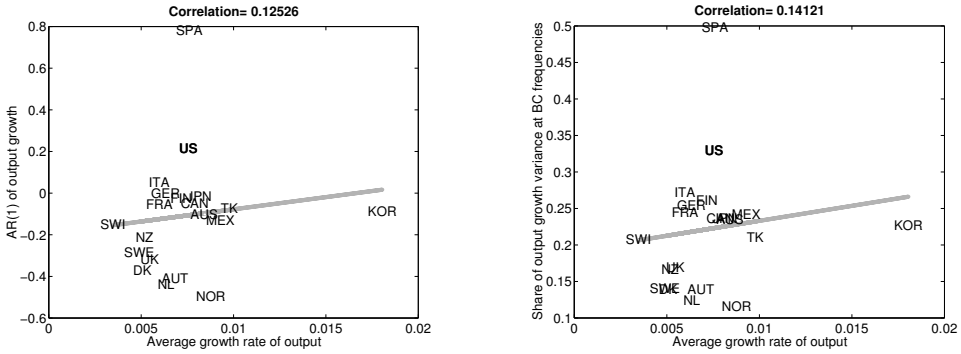

Figure 9: Output persistence and capital intensity

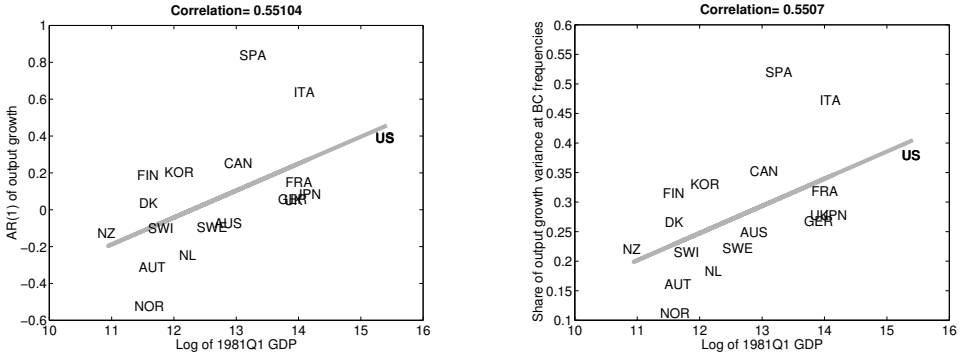

Figure 10: Output persistence and variance of output growth rate