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Persistent Growth: An International Perspective

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PRELIMINARY AND INCOMPLETE

ABSTRACT

Recent literature has shown that standard closed economy models of real business cycle fail to reproduce the persistence of aggregate variables growth rates observed in the data. We document that existing open-economy business cycle models suffer the same shortcoming. We thus develop a two-country two-sector model that is able to match the persistence of output and investment growth observed in the data. The novel feature that drives the result is the interplay between international and intersectoral reallocation in response to differential productivity shocks across countries.

1. Introduction

In their seminal paper Cogley and Nason [12] highlight a major discrepancy between Real Business Cycle (RBC) theory and data: existing RBC models have weak internal propagation mechanisms and do not generate the positive autocorrelation in output growth observed in the data. In the standard RBC model when the economy is hit by a one-period positive shock, labor and investment rise on impact but then monotonically decline, generating a weakly negative autocorrelation of output growth over short horizons. This is in contrast with the empirical observation that output growth is persistent: it lasts more than one period giving rise to an humped shaped transitory impulse-response function.

A large and growing number of studies have tried to reconcile theory and empirical evidence along this dimension. Andolfatto [2] shows that it is possible to generate some persistence in output growth by explicitly modelling matching frictions in the labor market. In this model the optimal adjustment of labor to a technology shock takes several periods, inducing persistence in employment growth. When this effect is strong enough to offset the monotonic decay of technological shock and investment, the resulting output dynamics displays positive autocorrelation. Carlstrom and Fuerst [11] on the other hand make investment persistent by introducing endogenous agency costs. In their model the hump-shaped output behavior arises because households delay their investment decisions until agency costs are at their lowest, a point in time several periods after the initial shock.

Since output is a function of factor inputs, these models generate persistence in output growth by spreading the optimal adjustment of factor inputs through time via the introduction of some sort of friction in the factor markets. Perli and Sakellaris [17] propose a different approach: they study how much persistence of output growth can be generated in a multi-sector model where total output is now a function of the output generated by different sectors. This model generates persistence through the intrasectorial reallocation of resources that follows a technology shock. On impact resources are shifted from the consumption to the investment sector. For some parameter values this reallocation induces an increase in the output of the investment sector that more than offset the decline in the consumption sector. As a result aggregate output increases on impact and increases even further in the following period when agents increase consumption and reduce investment, generating positive autocorrelation of output growth.

All these studies share a common feature: they focus on the sources of persistence in a closed economy.

In this paper we follow a different approach and study the persistence properties of an open economy. In this context domestic output becomes a function of foreign investment that represents a new channel through which persistence of output growth can be induced. When agents are allowed to trade internationally, resources are reallocated in order to exploit productivity differentials across countries and the existence of frictions in international markets can spread the adjustment process through time generating positive autocorrelation of output growth via the persistent growth of foreign investment. In this context our objective is to quantify the persistence of output growth that can be generated through this channel. In particular, we show that a two-country model with two sectors in each country, one producing for the domestic market and the other exporting, is able to generate the same persistence of investments and output growth observed in the data. In this model the interplay between international and intrasectorial reallocation of resources drives the result: following a positive shock in the home country, on impact the foreign country increases the output of the exporting sector by reallocating labor and shifts capital from the domestic to the exporting sector in order to export even more in the following period. This generates persistence of investment and output growth in the home country. It is interesting to note that the presence of two sectors is not, *per se*, an impediment to an instantaneous optimal adjustment but it becomes a binding constraint in the calibrated version of the model, where the parameters governing the share of the export sector in the economy and the productivity differentials across countries are such that the output in the tradable sector is not large enough to equalize marginal productivities on impact so that the optimal adjustment takes more than one period. In other words, rather than introducing another ad hoc friction hard or impossible to calibrate, we highlight a feature of the data that has an important role in generating persistence of output growth.

Section 2 of the paper describes the facts: we analyze data on the autocorrelation function of output, investment and employment growth for the industrialized countries and show the empirical regularities that we want the model to match. Section 3 lays out the complete general equilibrium two-country, two-sector model and Section 4 discusses calibration. The results are presented in Section 5 and than compared with those obtained by the existing models of international RBC in Section 6. We conclude in Section 7.

2. The data

So far persistence of output growth has been mainly studied in a closed economy context. As a consequence the empirical evidence relevant for this literature focuses on the analysis of the persistence properties of US aggregate variables only. On the other hand, international business cycles literature (Backus Kehoe and Kydland [4] [5]) focuses on the correlation of international variables and does not analyze their autocorrelation properties.

In this section we want to assess to what extent the positive autocorrelation of output growth that characterizes US data can be considered a general phenomenon. We thus extend the analysis of Cogley and Nason and compare the persistence properties of output growth across all the G7 countries. Moreover, to better understand the sources of persistent growth, we complete the analysis by including data on the autocorrelation function of output determinants in an open economy.

Following Cogley and Nason we summarize the persistence properties of an aggregate time series with its autocorrelation function at several lags. The data on Europe are obtained from the aggregation[1] of the four European countries in the G7 (Germany, France Great Britain and Italy) but autocorrelation functions for the single countries are available upon request.

In Fig.1 we present the autocorrelation function of output, investment, labor and Solow residuals growth rates for Usa, Canada, Europe and Japan. It's immediate to note that all countries display positive autocorrelation of output growth over short horizons and that the magnitude of the phenomenon in Usa is in line with that of the other countries. Another common feature among countries is the very low autocorrelation of Solow residuals growth at all lags and the high persistence of investment and labor growth rates over short horizon. It follows that the sources of output growth persistence should be found in the endogenous response of factor inputs and not in the exogenous process governing the technological shock. Moreover, the autocorrelation of investment growth at the first lag is consistently higher than the autocorrelation of output growth while the autocorrelation of labor shows more

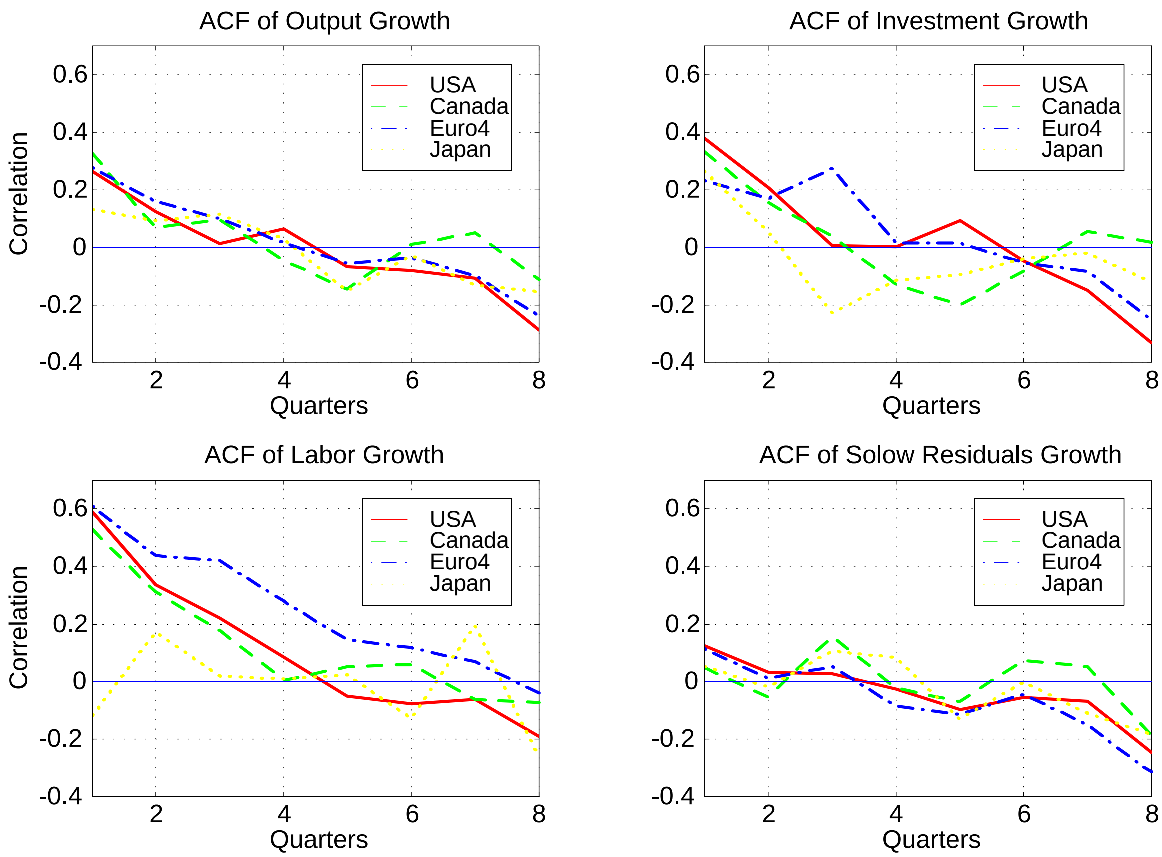
[1] Details on the aggregation procedure are in data appendix.

variability[2].

In Fig.2 we plot the autocorrelation function of export and import growth since in an open economy they are relevant in the determination of total output. We can notice that the growth of export is positively correlated at the first lag and negatively correlated at the second lag for all countries with the exception of Japan, while the autocorrelation of imports does not display a common pattern across countries but is in general close to 0 with the exception of Japan.

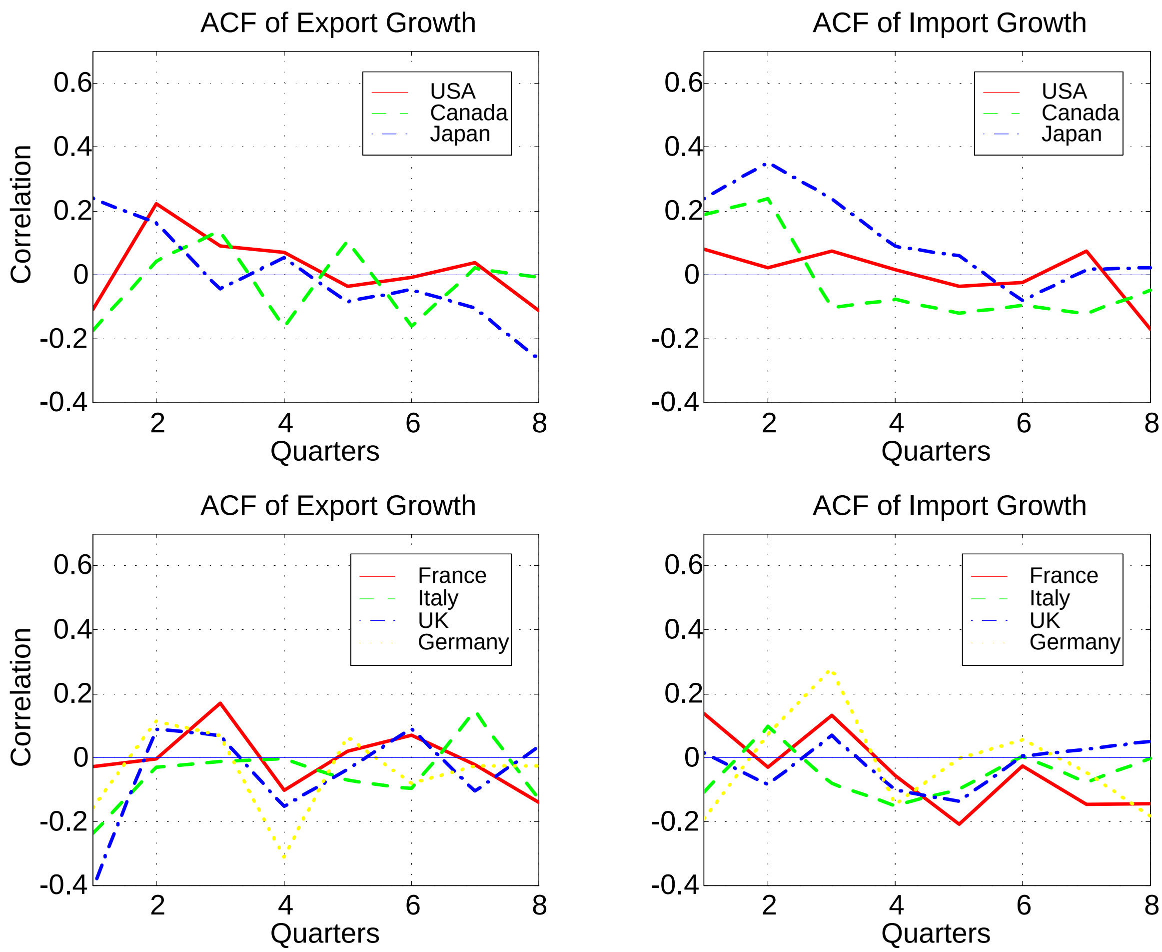
These data provide a useful benchmark against which we can compare the persistence properties of time series generated by any real business cycle model, whether of closed or open economy.

[2]The higher variability of the autocorrelation function of labor growth it also apparent by looking at European countries separately: the first order autocorrelation for labor rowth ranges from .08 for Italy to .76 for Germany.



ACF of Output Growth
ACF of Investment Growth
ACF of Labor Growth
ACF of Solow Residuals Growth
Correlation
Quarters
USA
Canada
Euro4
Japan
0.6
0.4
0.2
0
-0.2
-0.4
2
4
6
8

Figure 1:



ACF of Export Growth
ACF of Import Growth
Correlation
Quarters
USA
Canada
Japan
France
Italy
UK
Germany
0.6
0.4
0.2
0
-0.2
-0.4
2
4
6
8

Figure 2:

3. The model

Consider a world economy with two countries and two sectors for each country. Each country is populated by a large number of identical infinitely lived consumers. In each period t the economy experiences one event $s_t \in S$ where S is a possibly infinite set. We denote by s^t the history of events up to and including date t. The probability at date 0 of any particular history s^t is given by $\pi(s^t)$. Each sector produces a country specific final good using capital and labor. To fix ideas think of US (the home country) and UK (the foreign country) and think of the final good as cars. In United States there are two sectors, one producing cars with the steering wheel on the right side, sold on the US market, and one producing cars with the steering wheel on the left side, sold on the UK market. The same two sectors are present in the UK. In each country the "right" final good can be used for consumption or investment. We will call the sector that produces the good consumed and invested at home "domestic" and the sector that produces the good consumed and invested abroad "exporting". Consumers in both countries get utility only from the domestic good and they are indifferent to the origin of production (i.e. American consumers drive only cars with the steering wheel on the right side and they don't care whether they are produced in US or in UK) . Preference of the representative consumer in the home country can thus be described by

$$(1) \qquad \sum_{t=0}^{\infty} \sum_{s^t} \pi(s^t) \beta^t u(c(s^t), 1 - l_d(s^t) - l_e(s^t))$$

where $c(s^t)$ is consumption of the final good, $l_d(s^t)$ is labor in the domestic sector and $l_e(s^t)$ is labor in the exporting sector and the total time endowment of the consumer has been normalized to 1. Preferences of consumers in the foreign country are

$$\sum_{t=0}^{\infty}\sum_{s^t}\pi(s^t)\beta^t u(c^*(s^t), 1 - l_d^*(s^t) - l_e^*(s^t))$$

where a $*$ denotes a foreign variable.

In each country and in each sector there is a continuum of identical firms of measure 1,that have access to a decreasing return to scale technology. Firms in the home country are owned by home consumers and they choose investment and employment plans so to maximize the value of their dividends $d(s^t)$ discounted at the intertemporal price[3] of the domestic good $q(s^t)$.

The time 0 problem for a firm producing the domestic good can thus be written as

$$\max_{k_d(s^{t+1}),l_d(s^t)}\sum_{t=0}\sum_{s^t} q(s^t)d_d(s^t)$$

where the dividends paid, $d_d(s^t)$ are given by

$$d_d(s^t) = z(s^t)\left(F(k_d(s^t), l_d(s^t))\right)^v - w(s^t)l_d(s^t) - k_d(s^{t+1}) + (1-\delta)k_d(s^t) \tag{2}$$

The time 0 problem for firms producing the exporting good is

$$\max_{k_e(s^t),l_e(s^t)}\sum_{t=0}\sum_{s^t} q(s^t)d_e(s^t)$$

where the dividends (in terms of the domestic good) paid, $d_e(s^t)$ are given by

$$d_e(s^t) = p(s^t)z(s^t)\left(AF(k_e(s^t), l_e(s^t))\right)^v - w(s^t)l_e(s^t) - k_e(s^{t+1}) + (1-\delta)k_e(s^t) \tag{3}$$

where F is a constant return to scale production function, v is a parameter between 0 and 1 capturing the degree of decreasing returns, A is a parameter capturing permanent differences

[3] $q(s^t)$ is the the time 0 price of a unit of the domestic good in state s^t.

in productivity between the two sectors, $z(s^t)$ is an aggregate (common across sector) productivity shock, $w(s^t)$ is the wage (equalized across sectors) in terms of the domestic good , $p(s^t)$ is the price of the exported good in terms of the domestic good (the real exchange rate or the terms of trade) and $k_d(s^t)$ and $k_e(s^t)$ are the capital stock in place in the two sectors in state s^t.

Notice here (from 2 and 3) the assumption that capital in both sectors is composed only of domestic good: that implies that the technology of the exporting sector has a joint output of exporting good $(z(s^t)\left(AF(k_e(s^t), l_e(s^t))\right)^v)$ and domestic good $((1-\delta)k_e(s^t))$.

Notice also that the assumption of decreasing returns to scale implies that firms will make positive profits in equilibrium. There are two reasons for making this assumption: the first is to determine (together with a productivity differential) the equilibrium the size of the two sectors and the second is to avoid a excessive capital movements from the less to the more productive country.

The problem of the firm in the foreign country is similar and is omitted for brevity.

Since we assume the existence of complete markets we can write the Arrow Debreu budget constraint (in term of the home good) of home consumers as

$$(4)\qquad \sum_{t=0}\sum_{s^t} q(s^t)\left[w(s^t)(l_e(s^t)+l_d(s^t))+d_e(s^t)+d_d(s^t)\right]=\sum_{t=0}\sum_{s^t} q(s^t)c(s^t)$$

while the budget constraint (in terms of the foreign good) faced by consumers in the foreign country is

$$(5)\qquad \sum_{t=0}\sum_{s^t} q^*(s^t)\left[w^*(s^t)(l_e^*(s^t)+l_d^*(s^t))+d_e^*(s^t)+d_d^*(s^t)\right]=\sum_{t=0}\sum_{s^t} q^*(s^t)c^*(s^t)$$

The problem of the consumers is the usual of maximizing utility 1 (**??**) subject to the budget constraint 4 (.5)

An equilibrium for this economy is defined in the standard fashion that is a collection of sequences for prices and quantities such that when agents and firms solve their problem taking prices as given the optimal quantities are such that markets for goods and factors clear.

In order to characterize the equilibrium we write the first order condition for the agents and for the firms and the market clearing conditions. For notational brevity let $u_c(s^t) = u_c(c(s^t), 1 - l(s^t) - l_e^f(s^t))$, $u_l(s^t) = u_l(c(s^t), 1 - l(s^t) - l_e^f(s^t)$,

$mpk_d(s^t) = z(s^t)v\left(F(k_d(s^t), l_d(s^t))\right)^{v-1} F_k(k_d(s^t), l_d(s^t))$,

$mpk_e(s^t) = z(s^t)vA^v\left(F(k_e(s^t), l_e(s^t))\right)^{v-1} F_k(k_e(s^t), l_e(s^t))$ and similar expression for $mpl_e(s^t)$ and $mpl_e(s^t)$.

First order conditions for consumers are

$$q(s^t) = \beta^t \pi(s^t) u_c(s^t) \quad \forall s^t$$

$$w(s^t) = \frac{u_l(s^t)}{u_c(s^t)} \quad \forall s^t$$

where

First order conditions for the firm producing the domestic good are

$$q(s^t) = \sum_{s^{t+1}} q(s^{t+1}) \left[mpk_d(s^{t+1}) + 1 - \delta\right] \tag{6}$$

$$mpl_d(s^t) = w(s^t) \tag{7}$$

while those for firms producing the exporting good are

$$q(s^t) = \sum_{s^{t+1}} \left[p(s^{t+1})q(s^{t+1})mpk_e(s^{t+1}) + 1 - \delta\right] \tag{8}$$

$$p(s^t)mpl_e(s^t) = w(s^t) \tag{9}$$

Combining first order conditions of firms and of consumers we obtain the Euler equations for the home country

$$u_c(s^t) = \beta \sum_{s^{t+1}} \pi(s^{t+1}|s^t) u_c(s^{t+1}) \left[mpk_d(s^{t+1}) + 1 - \delta \right]$$

$$u_c(s^t) = \beta \sum_{s^{t+1}} \pi(s^{t+1}|s^t) u_c(s^{t+1}) \left[p(s^{t+1}) mpk_e(s^{t+1}) + 1 - \delta \right]$$

and similar ones for the foreign country.

The efficiency conditions for the labor-leisure decisions in both sectors in the home country are

$$mpl_d(s^t) = \frac{u_l(s^t)}{u_c(s^t)} = w(s^t)$$

$$p(s^t) mpl_e(s^t) = \frac{u_l(s^t)}{u_c(s^t)} = w(s^t)$$

Intertemporal arbitrage (implied by the assumption of complete markets) implies also that

$$p(s^t) = \frac{q^*(s^t)}{q(s^t)} \frac{1}{p(s^0)}$$

and normalizing $p(s^0)$ to 1 we have

$$p(s^t) = \frac{q^*(s^t)}{q(s^t)} = \frac{u_c^*(s^t)}{u_c(s^t)}$$

We finally need the market clearing conditions for the two consumption goods

$$\begin{aligned} & z(s^t) \left(F(k_d(s^t), l_d(s^t)) \right)^v + (1-\delta)(k_d(s^t) + k_e(s^t)) + z^*(s^t) \left(AF(k_e^*(s^t), l_e^*(s^t)) \right)^v \\ = \quad & c(s^t) + k_d(s^{t+1}) + k_e(s^{t+1}) \end{aligned}$$

$$
\begin{aligned}
& z^*(s^t)\left(F(k_d^*(s^t), l_d^*(s^t))\right)^v + (1-\delta)(k_d^*(s^t) + k_e^*(s^t)) + z(s^t)\left(AF(k_e(s^t), l_e(s^t))\right)^v \\
= \;& c^*(s^t) + k_d^*(s^{t+1}) + k_e^*(s^{t+1})
\end{aligned}
$$

for every s^t.

We can also define aggregate output for each country as

$$y(s^t) = y_d(s^t) + p(s^t) y_e(s^t)$$

and

$$y^*(s^t) = y_d^*(s^t) + \frac{y_e^*(s^t)}{p(s^t)}$$

while aggregate investment and aggregate labor are simply given by the sum of labor and investment respectively, in the two sectors.

We will also consider a version of this model in which we introduce a small cost of adjusting the capital stock..

4. Measurement and Calibration

A. Parameters values and Functional Forms

In order to solve a linearized version of the above model we assume the following functional forms

$$F(k, l) = k^\alpha l^{1-\alpha}$$

$$u(c, 1-l-l_e) = \frac{\left[c^\mu (1-l-l_e)^{1-\mu}\right]^{1-\sigma}}{1-\sigma}$$

The steady state equations are (the steady state price of the foreign good in terms of the domestic good is 1)

$$(10) \quad \rho + \delta = \frac{v y_e \alpha}{k_e}$$

$$(11) \quad \rho + \delta = \frac{v y_d \alpha}{k_d}$$

$$(12) \quad \frac{c}{1 - l_e - l_d} \frac{1-\mu}{\mu} = \frac{v y_d (1-\alpha)}{l_d}$$

$$(13) \quad \frac{c}{1 - l_e - l_d} \frac{1-\mu}{\mu} = \frac{v y_e (1-\alpha)}{l_e}$$

$$(14) \quad y_d + y_e = c + \delta(k_d + k_e)$$

$$(15) \quad y_d = k_d^{\alpha v} l_d^{(1-\alpha)v}$$

$$(16) \quad y_e = A^v k_e^{\alpha v} l_e^{(1-\alpha)v}$$

where $\rho = \frac{1}{\beta} - 1$ is the risk free rate implied by this model.

There are seven parameters to be determined $A, v, \alpha, \mu, \delta, \beta, \sigma$

The calibration strategy is as follows: we use the steady state relations and observations on long term averages of variables in the US economy to derive values for the set of the first six parameters. Finally we set the risk aversion parameter to 2, and also we conduct some sensitivity analysis.

From 10 and 11 and 12 and 13 we get $\frac{k}{k_e} = \frac{l}{l_e} = \frac{y}{y_e} = R$ (R denotes the output ratio between the domestic and the exporting sector) that in turns implies that capital output ratios and capital-labor ratios are equalized across sectors. We can then use 15 and 16 to get an expression for A (for any given v)

$$A = \left(\frac{y}{y_e}\right)^{\frac{v-1}{v}} = R^{\frac{v-1}{v}}$$

We then use long run observations on the capital output ratio and consumption output ratio($c/(y+y_e)$) to get δ from 14

$$\delta = \frac{1-c/(y+y_e)}{\frac{k+k_e}{y+y_e}}$$

v and α are simultaneously determined by equalizing the labor share in the data to $(1-\alpha)v$,the labor share in our model,and the risk free rate in the data to $\frac{v\alpha}{\frac{k+k_e}{y+y_e}} - \delta$,the risk free rate in the model (from 10 or 11 and from the fact that capital output ratios are equalized across sectors)).

Finally μ is calibrated from the observation that fraction of time spent working $L = l + l_e$ is about one third and from 12 or 13 that imply

$$\mu = \frac{1}{1+\Phi}$$

where $\Phi = \frac{v(1-\alpha)}{\frac{c}{y}} \frac{1-L}{\frac{R}{R+1}L}$.

Long term averages for the capital-output ratio, the consumption-output ratio, the risk free rate, the fraction of times spent working and the labor share are chosen in conformity to most business cycle studies (see Cooley and Prescott 1995) and they are reported below. Since R in our model is equal to the ratio between output in the exporting sector and output in the domestic sector we determine it by computing the average ratio between exports and GDP-exports in the US economy in the years 1960-1997. In table 1and 2 we summarize the parameters used in our simulations and the long term averages that the steady state of the model reproduces.

Table 1. Parameter Values

Technology	
A	.89
α	.57
v	.95
δ	.025
Preferences	
β	.99
μ	.32
σ	2.0

Table 2. Observations

Capital-Output Ratio (Quarterly)	10
Consumption-Output Ratio	.75
Ratio of Exports to (GDP-exp)	.07
Labor Share	.6
Fraction of Time spent Working	.3
Risk Free Rate (Quarterly)	1%

B. Computing Total Factor Productivity

Due to the existence of two sectors the series for total factor productivity (Solow residuals) cannot be computed as in the standard one-sector growth model. We will briefly sketch how to modify the standard growth accounting for computing Solow residuals.

From the firms' first order condition in both sectors 6, 7, 8 and 9 we get

$$\frac{y_d(s^t)}{y_e(s^t)} = \frac{l_d(s^t)}{l_e(s^t)} p(s^t)$$

$$\frac{y_d(s^t)}{y_e(s^t)} = \frac{k_d(s^t)}{k_e(s^t)} p(s^t)$$

and thus

$$(17) \quad \frac{l_d(s^t)}{l_e(s^t)} = \frac{k_d(s^t)}{k_e(s^t)} = \frac{y_d(s^t)}{p(s^t)y_e(s^t)} = R(s^t)$$

where $R(s^t)$ is the ratio between output in the domestic and in the exporting sector in state s^t From 17 we can write the inputs employed in each sector as a time varying fraction of aggregate inputs i.e.

$$\begin{aligned}
l_d(s^t) &= \frac{R(s^t)}{1+R(s^t)} l(s^t) \\
k_d(s^t) &= \frac{R(s^t)}{1+R(s^t)} k(s^t) \\
l_e(s^t) &= \frac{1}{1+R(s^t)} l(s^t) \\
l_e(s^t) &= \frac{1}{1+R(s^t)} l(s^t)
\end{aligned}$$

we can then substitute these expressions into the expression for total factor productivity

$$\log z(s^t) = \log y(s^t) - \log \left[k_d(s^t)^{\alpha v} l_d(s^t)^{(1-\alpha)v} + p(s^t) A k_e(s^t)^{\alpha v} l_e(s^t)^{(1-\alpha)v} \right]$$

and get

$$\begin{aligned}
(18) \qquad & \log z(s^t) \\
= \; & \log y(s^t) - \alpha v \log k(s^t) - (1-\alpha) v \log l(s^t) \\
& - \log \left[\left(\frac{R(s^t)}{1+R(s^t)} \right)^v + p(s^t) A^v \left(\frac{1}{1+R(s^t)} \right)^v \right]
\end{aligned}$$

Notice form 18 that total factor productivity can be expressed as aggregate output (the first term) minus total inputs (the second and third term) minus an additional term capturing factor reallocation and price changes. Also when $v = 1$, $A = 1$ and $p(s^t) = 1$ the model nests the standard one sector growth model and the third term in 18 disappears.

The series for $\log z(s^t)$.can be computed from the data using 18. The empirical counterparts of $y(s^t), k(s^t)$ and $l(s^t)$ are the series for GDP, total capital stock and total employment while $R(s^t)$ is given by the ratio between GDP minus exports and exports and $p(s^t)$ is given by the terms of trade. Once the series for Total Factor Productivity for US and Europe[4] are computed we estimated a bi-variate stochastic process of the form

$$\begin{matrix} z(s^t) \\ z^*(s^t) \end{matrix} = A \begin{matrix} z(s^{t-1}) \\ z^*(s^{t-1}) \end{matrix} + \begin{matrix} \varepsilon(s^t) \\ \varepsilon^*(s^t) \end{matrix}$$

where $\begin{matrix} \varepsilon(s^t) \\ \varepsilon^*(s^t) \end{matrix}$ are normally distributed with variance covariance matrix Σ. Below we report the values for A and Σ.

$$A = \begin{pmatrix} .99 & 0 \\ 0 & .99 \end{pmatrix}, \Sigma = .009 \begin{pmatrix} 1 & 0.27 \\ 0.27 & 1 \end{pmatrix}$$

5. Results

In this section we compare the persistence properties of our model (without and with adjustment costs) with those displayed by the data. Following Cogley and Nason we compare the autocorrelation function (ACF) for the aggregate variables growth rates generated by the model with that calculated on US data (1954-1995).

[4] The details of the data used are in the data appendix

While the standard model of closed economy generates an autocorrelation function completely flat at zero at every lag for output, investment and labor growth rates, the two-country two-sector model delivers for all these variables significantly positive autocorrelation over short horizons. In particular, the autocorrelation of output and investment growth at the first lag is very similar to that observed in the data with the autocorrelation of investment larger than that of output. The autocorrelation for labor growth is significantly positive and in the model with adjustment costs it matches the one observed in the data. In this model, with no frictions in the labor market, this persistence in labor derives from the high autocorrelation of the investment given the complementarity of labor and capital in the production function.

As in the data we find that the autocorrelation of export growth is negative at the first lag and positive at the second lag while that of imports and Solow residuals are never significant.

Also to provide intuition on the propagation mechanism in our model we present impulse responses to a 1% productivity shock in country 1 for the main macroeconomic aggregates. Finally in table 3 we present the main business cycle statistics computed from the model and we compare them with the same statistics on US data TO BE COMPLETED

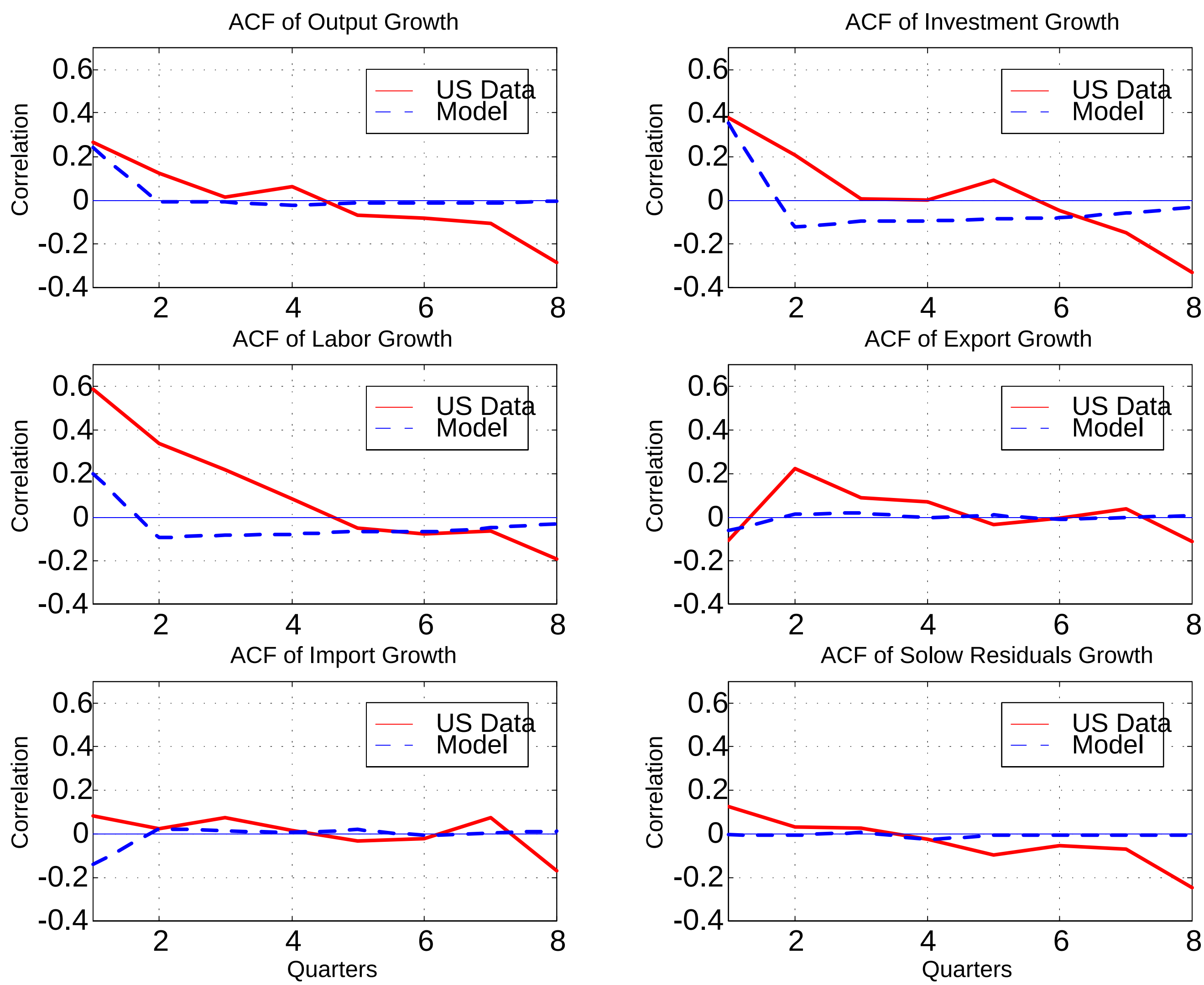


Figure 3: Model without Adjustment Costs

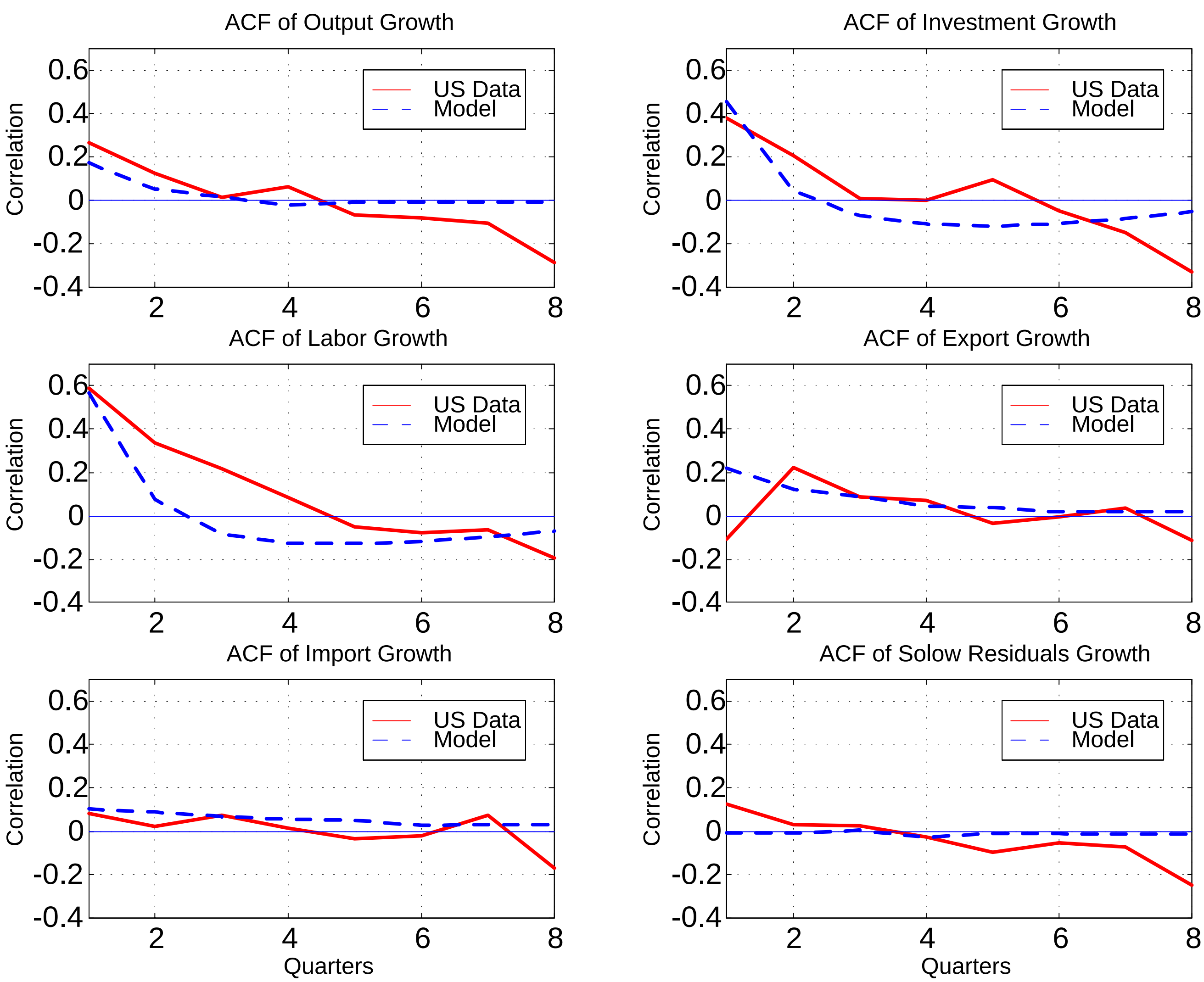


Figure 4: Model with Adjustment Costs

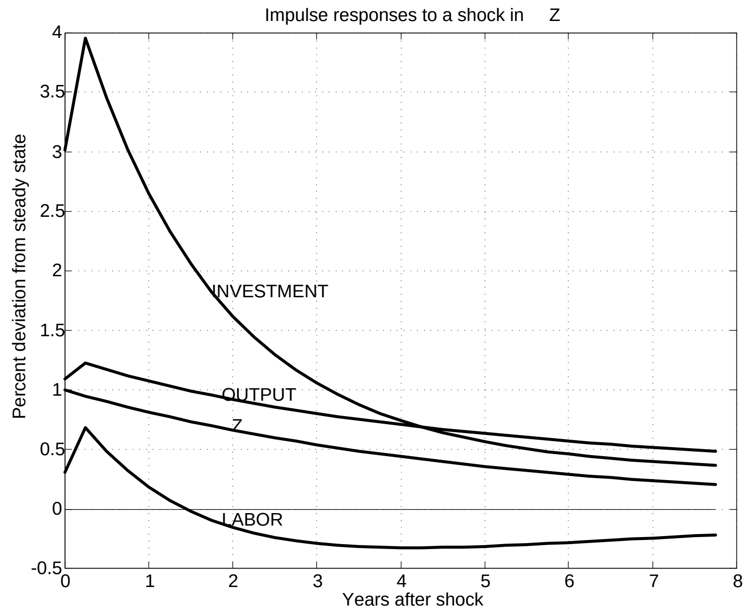


Figure 5:

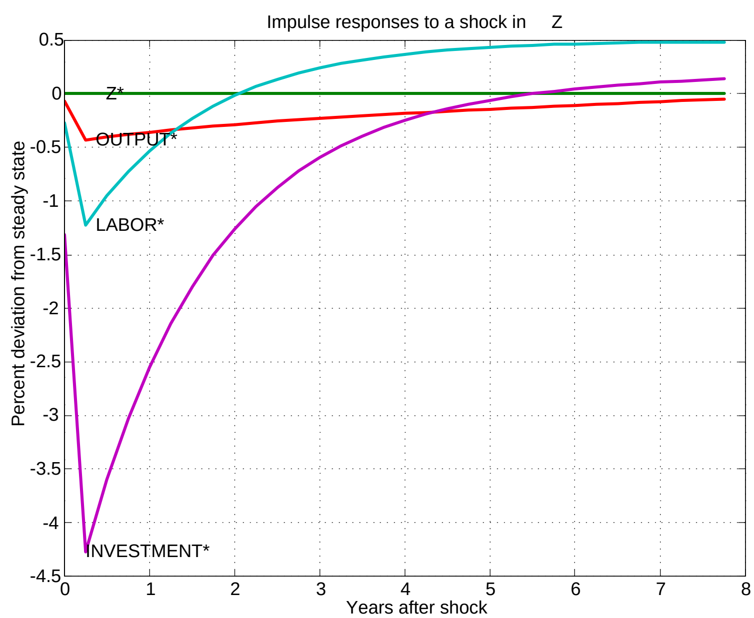


Figure 6:

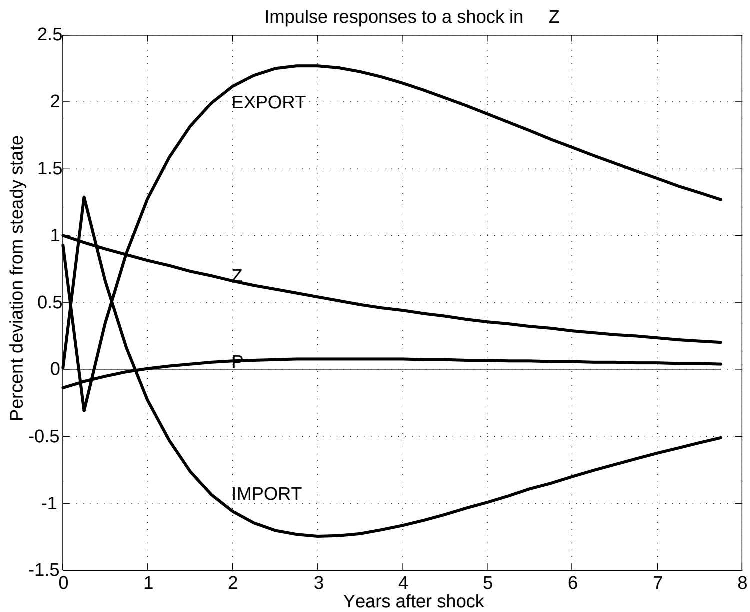


Figure 7:

Table 3 - Business Cycles Statistics

Standard Deviations

		Relative to Output						
	y	c	x	n	nx	exp	imp	p
US Data	1.92	.75	3.27	.61	.52	5.52	4.90	2.92
Model	1.30	.57	4.34	1.15	.68	3.90	3.65	.31

Correlations

	y,y^*	c,c^*	x,x^*	n,n^*	y,nx	y,p	p,nx
US/Euro Data	.66	.51	.53	.33	-.37	-.20	.30
Model	-.23	.76	-.91	-.99	-.42	-.48	.67

6. Comparisons with Existing Models

In this section we present the autocorrelation functions generated by a standard international business cycle model with one good and one sector for each country and adjustment costs on investment. We see that the lack of the propagation mechanism characteristic of the closed economy models is still present here and the autocorrelations are mainly flat. The same result obtains if one computes the autocorrelation generated by a two good model as the one of Backus Kehoe and Kydland (1995). The reason is that also a two good model lacks the mechanism of sectorial reallocation in response to international shocks that drives the persistence results of our model..

7. Conclusions

One of the main shortcomings of real business cycle models is the lack of a propagation mechanism that amplifies and transmit the effect of technological shocks on the growth of output and of factor of production.. In this paper we suggest that international linkages might provide such a mechanism. We present a model in which international differential in productivity triggers sectorial reallocation. In response to positive productivity shocks in the home country resources are transferred from abroad. The international transfer is achieved shifting resources from the sector producing for the domestic markets to the exporting sector. This entire process takes time due the existence of fixed factors and thus we observe persistent effects of productivity shocks on the growth of macro-variables. The model presented is able to generate autocorrelation functions for the growth of output, investment and labor that are similar to those observed in the data for the g7 countries.

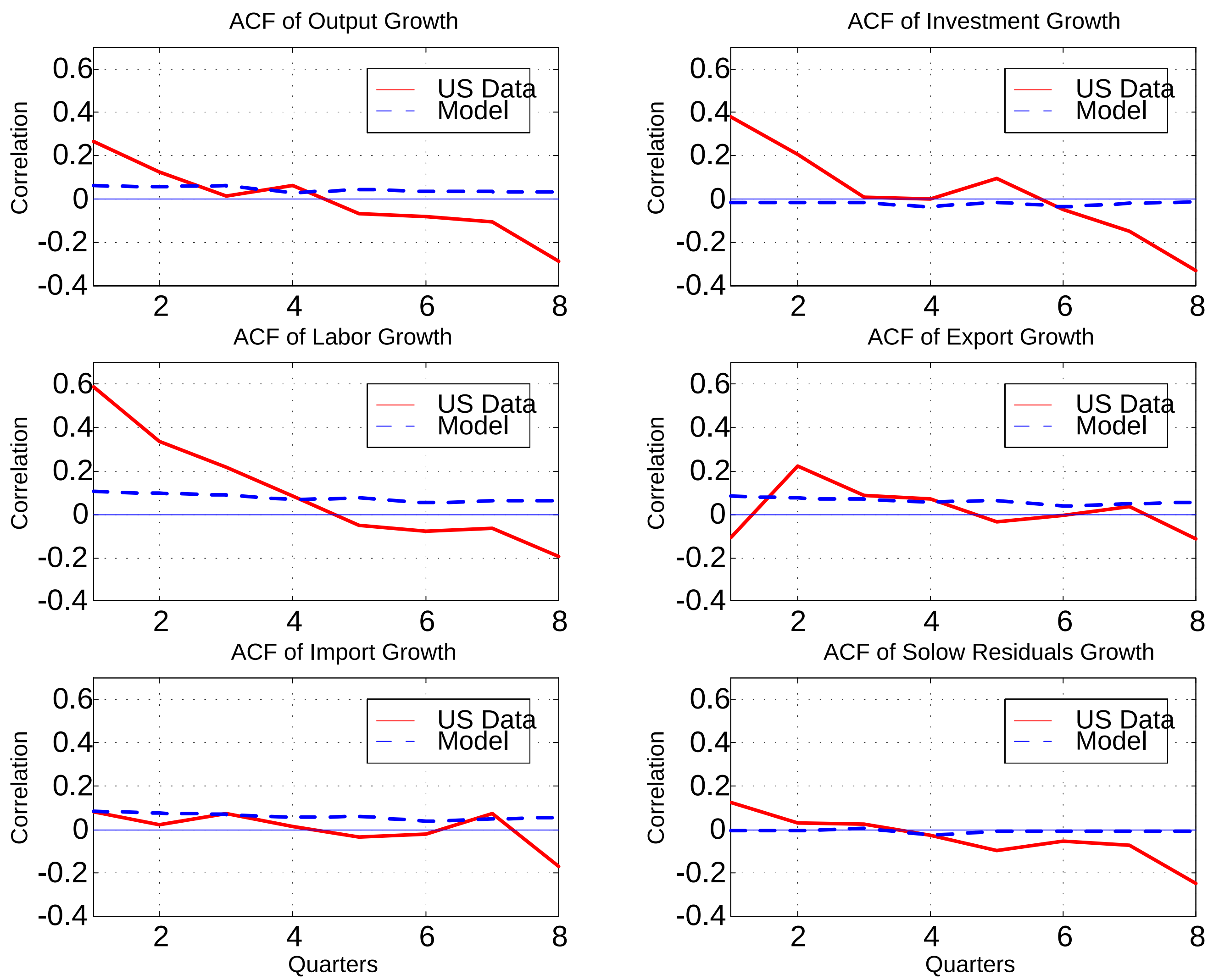


Figure 8: Standard IRBC model (Baxter and Crucini)

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