Export-Led Recoveries in Small Open Industrialized Economies

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Abstract

This paper studies the role of Vertical Specialization-based trade and foreign damand push as elements capable of explaining export-led recoveries in small open industrialized economies.

The empirical evidence on export-led recoveries is reviewed. Data supporting the growing importance of vertical specialization for international trade are presented.

I compare the performance of two versions of a small open economy model, calibrated to mimic Canadian Business Cycles. The first one is based upon Schmitt-Grohe(1998). The second incorporates Vertical-Specialization-based trade.

I show that an artificial economy featuring Vertical-Specialization-based trade in conjunction with an exogenous AR(2) process for foreign output displays improved impulse responses to a foreign output shock and is able to mimic the contribution of Canadian exports to output growth during economic recoveries.

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1 Introduction

The export-led recovery hypothesis refers to a positive response of exports as well as imports after an external positive shock. The idea is that a recovery episode is triggered by good external conditions which are able to drive a small open economy back to prosperity via increasing exports.

A booming economy, driven by exports, will demand more foreign goods if the technology used to produce export goods relies heavily on imports as inputs. The last sentence introduces a nexus between export-led recoveries and the trade pattern adopted by a particular country.

In the following paragraphs, I will present two different trade patterns. The discussion will be crucial for the understanding of the artificial economies I intend to study.

The world's economies are becoming more integrated. Rather than concentrate production in a single country, firms are increasingly using an internationalized production structure. One of the most important features of internationalized production systems is the integration of production processes in a vertical trading chain, encompassing more than one country.

In this new paradigm, there is a sequential linkage in which a country imports a good from another country and uses that good as an input in the production of its own export good. The chain of production can be quite extensive and can stretch across many countries, with each country becoming specialized in particular stages of production. Trade Economists use the terminology *vertical specialization*(VS for short) to label this mode of production. On the other hand, *horizontal specialization*(HS hereafter) is a trade pattern in which countries trade goods that are produced from start to finish in just one country.

A production structure which emphasizes the use of imported goods as inputs to produce a country's export goods is summarizing two ideas. The first is that the sequence of production related to a particular good involves at least two countries. The second is that during this sequence the good in process crosses at least two international borders or the same border twice. The latter idea is associated with the back-and-forth aspect of international trade in goods.

For instance, the United States produce engines or parts that are exported to Canada, where they are used as inputs in the assembling process of final motor vehicles that are exported back to the United States. In effect, the back-and-forth nature of modern trade is absent from traditional versions of international real business cycle models.

The aim of my paper is to study the role of vertical-specialization-based trade in conjunction with movements on foreign output as important elements for export-led recoveries.

I compare the performance of two small open economy models according to the following metrics: second moments, the response of trade variables to a world output shock and the role of trade balance and exports in economic recovery episodes. The first model studied is a standard small open RBC economy . The second features vertical-specialization-based trade.

Standard international real business cycle models focus on horizontal-specialization-based trade. In these models a country specific good is used as an input to the final good sector and is also exported. In other words, imports are not used in the production of export goods.

This paper extends a basic RBC artificial economy in order to include vertical specialization. The model links imports to exports directly, since imports are used as inputs to produce exports.

The chain of production considered in the VS version is a very simple one, characterized by two stages. The small open economy specializes in processing intermediate imports coming from the rest of the world, where the first stage takes place.

The models are calibrated using Canadian data and the rest of the world is defined as the United States.

The paper is organized in six additional sections. The second section reviews the empirical evidence supporting the notion of export-led recoveries. The third documents the effects of US output fluctuations on the Canadian trade dynamics. The fourth presents a standard small open economy model. The fifth reviews data supporting the growing importance of vertical specialization for international trade. The sixth section presents a small open economy model with vertical-specialization-based trade. The final section concludes.

2 Export-Led Recoveries: the empirical evidence

This section is an attempt to summarize the results presented in Prasad and Gable(1997), which is an empirical paper addressing the determinants of trade dynamics. The third section studies the role of international trade in short-term macroeconomic fluctuations for small industrial economies .

Usually, the external sector is viewed as being an important force behind business cycle recoveries. In the context of national income accounting identity, net trade would appear to be the relevant macroeconomic variable associated with economic recoveries. Nevertheless, an alternative idea is that export demand, rather than net exports, is the catalyst for economic recovery.

Export-led recoveries are compatible with a concomitant increase in imports of intermediate inputs. Consequently, the trade balance could deteriorate despite the export stimulus to domestic demand.

To address the plausibility of export-led recoveries, Prasad and Gable propose a way to measure empirically the contribution of the trade balance to output growth from business cycle troughs. The contribution of exports to output growth from business cycle troughs is also evaluated using the same method.

The first step is the identification of business cycle troughs. For each country, one has to take the logarithm of quarterly GDP and use the H-P filter to get the stationary component of output. After that, one has to look at episodes characterized by a one and a half percentage negative deviation of output from its trend.

By examining these episodes, it is possible to identify recessions and build intervals associated with starts and ends of recessions. The cyclical trough can be found just by looking at the quarter in which the cyclical component of output reaches its lowest level within a recession episode.

The formula for calculating the growth contribution of a trade related variable over different time horizons is as follows:

$$CB(j) = \frac{TRV(t+j) - TRV(t)}{Y(t)} \tag{1}$$

Notation: CB(j) indicates the contribution to output growth over a j-period horizon from cyclical trough, TRV(.) indicates the trade related variable(trade balance or exports) in a particular point in time. Time **t** is associated with a cyclical trough and Y(t) denotes aggregate GDP at time **t**.

The measure proposed by Prasad and Gable indicates how much output would have increased relative to its level at the trough if domestic demand remained unchanged, isolating the direct contribution of trade balance or exports to output recoveries.

I present two tables which summarize the role of external sector in economic recoveries.

The first table reports the average contribution of the trade balance to output growth over different horizons ranging from one to twelve quarters from a cyclical trough. The average is taken over recession episodes.

The second table reports the average contribution of exports to output growth ranging from one to twelve quarters after a cyclical trough.

It is important to remind the reader that the tables below are abbreviated versions of a much more complete set of tables presented in Prasad and Gable(1997).

Table 1-Contribution of trade balance to output growth(%)					
country	t+1	t+2	t+4	t+8	t+12
Australia	0.28	-0.41	-0.54	-0.35	-1.52
Canada	-0.17	-0.22	-1.08	0.13	-0.69
Denmark	-0.02	-0.99	-0.63	-1.27	-3.12
France	-0.31	-0.24	-1.06	0.01	0.50
Germany	-0.14	-0.40	-0.60	0.68	0.50
Japan	-0.31	-0.32	-0.43	-0.93	-0.15
Netherlands	0.94	0.82	0.69	0.13	-0.46
UK	-0.14	-0.04	0.13	0.64	0.32
USA	0.07	-0.36	-0.68	-1.41	-1.47

Table 2-Contribution of exports to output growth(%)					
country	t+1	t+2	t+4	t+8	t+12
Australia	0.10	0.10	1.12	2.59	3.20
Canada	0.52	1.05	2.45	6.28	7.69
Denmark	0.38	0.06	1.45	3.72	3.13
France	0.46	1.65	1.86	3.90	5.70
Germany	0.13	0.24	1.31	3.40	4.01
Japan	0.04	0.06	0.74	1.61	2.81
Netherlands	1.85	2.75	4.69	6.24	7.17
UK	0.46	0.40	1.25	2.76	3.81
USA	-0.01	0.03	0.14	0.72	1.32

Looking at table one, it is easy to see notable differences across countries. For the majority of the OECD economies, including countries that are not in my table, the average contributions of the trade balance to output growth at four, eight and twelve quarter from cyclical troughs are negative or close to zero.

The main result reported in table two is that, for virtually all countries, exports contribution to cyclical recoveries is significant. Again, there are marked differences across countries.

For small industrialized open economies, like Canada and the Netherlands, exports seem to be working as a catalyst for cyclical recoveries, despite a small direct contribution from the trade balance to output growth.

For big economies, like Japan and the US, the notion of exports as the engine driving recoveries is not an accurate picture. Since these economies are considerably self-sufficient, exports are less important.

3 The Effect of US economic fluctuations on the Canadian Trade Dynamics

The empirical study in this section is based on Canada. A relevant question is 'why Canada?'. First, based on statistics to be presented in section five, vertical specialization seems to be an important characteristic of the Canadian economy and it is growing in its importance. Second, the export-led recovery hypothesis seems to apply to Canada as we can see just by examining the numbers in section two.

Moreover, data availability is not an issue when Canada is the subject of study and some important papers about small open economy business cycles have used Canada as a benchmark. An example is Schmitt-Grohe(1998).

Another possible subject for a paper like this one is Mexico. Mexican maquiladoras are an important example of vertical-specialized-based trade. The difficult task is to isolate the role of trade for recoveries in Mexico. Looking at Mexico would probably cloud the role of vertical specialization since monetary policy issues and foreign investors expectations are very important forces behind recent Mexican economic history.

Canada seems to be a good choice since the models studied in this paper are not monetary ones and my focus is essentially on trade patterns(vertical versus horizontal specialization).

3.1 Comovement with US Output

First, I document the simple fact that Canada and US move together. The comovement is not only related to oscillations of GDP but is also a phenomenon involving Canadian trade variables. Exports and Imports tend to comove with US GDP. The next table shows contemporaneous correlation between Canada and the US.

Table 3-Correlation with US Output				
Economy	Y	$\frac{\exp}{Y}$	$\frac{imp}{Y}$	$\frac{nx}{Y}$
Canada	0.62	0.4	0.52	-0.14

Figure One shows plots of cyclical components of Canadian trade variables and GDP against cyclical components of US output. I use the HP filter to extract the cyclical components and the data used are quarterly series from 1967 to 1998.

3.2 Empirical Impulse Responses

One of the metrics used to compare the models in question is the response of the external sector of a small open economy to shocks occurring in the rest of the world.

It is important to understand the dynamics of trade variables after a shock originated abroad for two reasons. First, the impulse responses can shed some light on the international transmission of business cycles and the role of trade as a transmission mechanism. Second, knowing the behavior of exports and imports after an external shock is relevant for export-led recoveries.

A brief description of the econometrics used is now in order. I estimate a set of bivariate VARs . The relevant variables are: GDP, the inverse of the terms of trade, exports and imports. All variables are associated with the Canadian economy. The idea is to estimate the response of the Canadian external sector to a US output shock. Following Schmitt-Grohe(1998), I use US GNP as the measure of economic activity for the rest of the world. Since I am considering a small economy, it is plausible to assume that US GNP innovations are exogenous.

I do not take a stand on particular shocks driving the rest of the world(US). Therefore, disturbances to US economic activity(GNP) can be viewed as the result of a myriad of particular shocks(fiscal, monetary and others) acting in a combined way.

I use quarterly data from 1967(Q1) to 1998(Q4) to estimate bivariate relationships between the logarithm of real US GNP and the logarithm of Canadian variables. I detrended the data before I start running the relevant regressions.

In my estimations, I use standard log-likelihood tests to determine the lag to be used. I do not present the statistics in question, it suffices to mention that for all regressions two was selected as the number of lags for each variable(Canadian trade variables and US GNP).

Figure number two summarizes the response of particular Canadian trade-related variables to a unit impulse in US output. The graphs show that GDP, exports and imports(as a fraction of GDP) respond qualitatively in the same way. These variables increase after the shock, reach a maximum more or less at the same time and decline smoothly towards zero.

Looking particularly at the response of exports and imports, it is possible to see that these variables respond quantitatively and qualitatively in the same way. Therefore, the impact on trade balance is not a very significant one.

The story summarized by the pictures goes as follows. After a good external shock, Canada responds positively with increasing GDP, exports and imports. As time goes by, the effect of the shock vanishes and the economy goes back to its steady state level.

The response of the inverse of the terms of trade is also shown. The magnitude of the response is not very significant. This result is in line with findings reported by Schmitt-Grohe(1998).

4 A Small Open Economy Model

I am about to present the basic equations describing the economic environments to be studied. The artificial economy is a version of a traditional international RBC model for a small open economy. It resembles artificial economies studied by Schmitt-Grohe(1998) and Senhadji(1998). The model is based upon the notion of horizontal-specialization-based trade, since there is no specific technology to produce exports using imports.

4.1 The Building Blocks

4.1.1 Households

The representative household in the small open economy has an infinite planning horizon and her(or his) utility function is given by:

$$U = E_0 \sum_{t=o}^{\infty} \beta^t u(C_t, L_t) \tag{2}$$

The momentary utility function is :

$$u = \log(C_t) + \gamma \log(L_t) \tag{3}$$

where the parameter γ is a positive number and β is the subjective discount factor.

The representative agent maximizes the utility function U subject to the following constraints:

- Time Constraint:

$$L_t + N_t = 1 \tag{4}$$

- Budget Constraint:

$$p_t C_t + p_t I_t (1 + \frac{\psi}{2}(\frac{I_t}{K_t})) + b_{t+1} \leq r_t K_t + w_t N_t + (r_t^* - \theta b_t) b_t \tag{5}$$

where capital accumulates according to :

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{6}$$

Some notation has to be explained. C_t, L_t, N_t stand for consumption, leisure and labor respectively. K_t and I_t denote capital and investment. δ stands for the depreciation rate and ψ is a parameter associated with intertemporal adjustment cost for investment. Prices for labor, capital and final goods are represented by w_t, r_t and p_t.

The small open economy can borrow abroad and the interest rate is a function of debt previously accumulated. Assuming that the interest rate is an increasing function of a country's debt is useful because it is a way to guarantee that the model will have a well defined steady state, avoiding unit roots which can undermine the linearization strategy used to solve the model.

Finally, b_t is the small open economy asset, r_t^* is an exogenous interest rate, which will be held constant in the simulations. In other words, I will not explore the foreign interest rate as a possible transmission mechanism for the propagation of shocks, sticking to my initial intent of studying patterns of trade and their relationship with some aspects of business cycles. θ controls how dependent on external debt interest rates are.

4.1.2 Firms

- Final Goods:

Firms engaged in the production of final goods maximize their profits, by solving the following optimization problem:

$$Max\{p_t V_t - pa_t A_1(t) - pb_t B_1(t)\} \tag{7}$$

subject to :

$$V_t = (wA_1(t)^\rho + (1-w)B_1(t)^\rho)^{\frac{1}{\rho}} \tag{8}$$

The decision variables are : $A_1(t)$ and $B_1(t)$. Additionally, I have to consider the restriction $\rho < 1$.

The elasticity of substitution is defined as: $\epsilon l = \frac{1}{1-\rho}$.

$A_1(t)$ is a domestic intermediate input and $B_1(t)$ is an imported intermediate good.

- Country-Specific Intermediate Good:

Firms in the intermediate good sector maximize their profits and hire capital and labor to produce an intermediate good which can be used domestically or exported. The amount of intermediate good used domestically is $A_1(t)$ and the amount exported is $A_2(t)$.

The representative firm's problem is :

$$Max\{py_t Y_t - r_t K_t - w_t N_t\} \tag{9}$$

subject to :

$$Y_t = Z_t N(t)^\alpha K(t)^{1-\alpha} \tag{10}$$

4.1.3 Market Clearing Conditions and Export Demand Function

- Market Clearing Conditions are:

$$V_t = C_t + I_t \tag{11}$$

$$Y_t = A_1(t) + A_2(t) \tag{12}$$

- Export Demand Function:

$$A_2(t) = \alpha_0 Y_w(t) p_x^{-\alpha_x} \tag{13}$$

Notation: $Y_w(t)$ stands for the world output and p_x is the export price. α_0 is just a scale parameter and α_x denotes the price-elasticity of export.

4.2 The Quantitative Exercise

The quantitative exercise involves a calibration stage, in which the basic parameters are assigned, and simulations.

First, I describe the forcing process used. I consider two exogenous shocks: a technology shock in line with the tradition in the RBC program and a foreign output shock. I assume that these shocks are not correlated. Initially, the foreign output follows an AR(1) process. I also consider an alternative case in which foreign output follows an AR(2) stochastic process. The parameters of the process are calculated via simple OLS regression.

The technology shock follows an AR(1) process. Parameters associated with the technology shock are set according to Canadian Solow residuals estimations.

The law of motion for the exogenous shock is:

$$s_t = P s_{t-1} + \epsilon_t \tag{14}$$

where the variance-covariance matrix for ϵ_t is Ω.

The AR(1) forcing process is described by the following specification.

$s_t = [y_w(t)\ z(t)]^T$. The stochastic exogenous process is written in log-linear form, so the vector s_t are log of foreign output and technological shocks.

$$P = \begin{bmatrix} 0.87 & 0 \\ 0 & 0.94 \end{bmatrix} \; and \; \Omega = \begin{bmatrix} 53 \times 10^{-6} & 0 \\ 0 & (0.008)^2 \end{bmatrix}$$

The AR(2) case is summarized by the following specification.

$$s_t = Ps_{t-1} + \begin{bmatrix} 1 & 0 \\ 0 & 0 \\ 0 & 1 \end{bmatrix} \epsilon_t \tag{15}$$

$s_t = [y_w(t) \; y_w(t-1) \; z(t)]^T$ and $\epsilon_t = [\; \epsilon_{Yw}(t) \; \epsilon_z(t)]^T$. Matrices P and Ω are given by the following expressions:

$$P = \begin{bmatrix} 1.25 & -0.33 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0.94 \end{bmatrix} \; and \; \Omega = \begin{bmatrix} 55 \times 10^{-6} & 0 \\ 0 & (0.008)^2 \end{bmatrix}$$

I use some values reported by Schmitt-Grohe(1998). Steady-state interest rate is 0.04, the share of net interest income received in GDP is -0.02, depreciation rate is 0.1, share of labor income in GDP is 0.68 , steady-state hours worked is 0.333. The values for elasticity of substitution are standard in international RBC models and correspond to empirical estimates.

Parameterization is summarized in the following tables.

Table 4-Parameters:basic						
δ	ψ	α	θ	w	α_x	β
0.1	0	0.68	10^{-6}	0.55	5	0.96

Table 5-Parameters: computed		
ϵl	γ	α_0
0.5	1.58	0.045
1.5	1.62	0.036
3	1.69	0.024

After the calibration stage is over, the first order conditions related to the models presented above are linearized using an algorithm described in Christiano(1998). Linear policy rules are obtained. The policy rules enable me to simulate the model in order to compute second moments, impulse responses and export-led recovery statistics.

4.3 Results

4.3.1 Standard Business Cycle Statistics

The tables below summarize how the model performs based upon its ability to replicate second moments associated with the data. The figures are based upon the AR(1) specification for the exogenous forcing process. The figures do not change much if one works with the AR(2) specification. Therefore I decide not to present the results related to the AR(2) process for the sake of brevity.

Table 6-Volatility				
Economy	$\sigma(Y)$ *in* %	$\frac{\sigma(C)}{\sigma(Y)}$	$\frac{\sigma(I)}{\sigma(Y)}$	$\frac{\sigma(N)}{\sigma(Y)}$
Canada	1.65	0.7	3.23	0.86
$\rho = 0.5$	1.67	0.37	3.52	0.36
$\rho = 1.5$	1.69	0.39	3.34	0.36
$\rho = 3$	1.63	0.43	3.06	0.36

Table 7-Volatility-Trade Variables(%)				
Economy	$\sigma(\frac{\exp}{Y})$	$\sigma(\frac{imp}{Y})$	$\sigma(ToT)$	$\sigma(\frac{nx}{Y})$
Canada	3.90	4.31	2.39	0.8
$\rho = 0.5$	1.03	0.75	0.46	0.79
$\rho = 1.5$	1.14	0.79	0.45	0.67
$\rho = 3$	0.81	0.65	0.25	0.31

Table 8-Correlation with Output			
Economy	C	I	N
Canada	0.77	0.78	0.82
$\rho = 0.5$	0.98	0.66	0.96
$\rho = 1.5$	0.97	0.71	0.96
$\rho = 3$	0.96	0.78	0.96

Table 9-Correlation with Output-Trade Variables				
Economy	$\frac{\exp}{Y}$	$\frac{imp}{Y}$	TOT	$\frac{nx}{Y}$
Canada	0.43	0.53	0.02	-0.1
$\rho = 0.5$	0.32	-0.12	0.83	0.24
$\rho = 1.5$	0.16	-0.37	0.81	0.23
$\rho = 3$	-0.02	-0.58	0.77	0.25

The model does not replicate perfectly important business cycle statistics. In fact, it underestimates exports, imports and terms of trade volatilities. Consumption and employment are also less volatile in my model. In addition, the model predicts countercyclical imports, procyclical net exports and a strongly procyclical terms of trade.

4.3.2 Impulse Responses

This section presents impulse responses related to the standard model. My goal is to compare the response of some instances of the standard model with the data. It is an exercise similar to the one undertaken by Schmitt-Grohe(1998). The idea here is to understand the transmission of shocks through variations in the terms of trade.

Figures three to six show the response of GDP, terms of trade, exports as a fraction of GDP and imports as a fraction of GDP to a shock to US output. The terms of trade are defined here as the relative price of imports in terms of exports.

Imports do not go up on impact when the elasticity of substitution is 1.5. By contrast, increasing the elasticity of substitution to three improves the response of imports to the foreign output shock. I do not present figures for an elasticity equal to 0.5 since they are qualitatively analogous to the plots associated with an elasticity of 1.5.

The AR(2) process is able to make the shape of the responses of GDP and exports look closer to their empirical counterparts. Unfortunately, in terms of magnitudes, no instances of the model deliver quantities compatible with the empirical impulse response functions.

4.3.3 Export-Led Recovery Statistics

The methodology described in section three is applied to artificial data generated by the standard model. Each instance of my model is simulated 500 times. For each simulation, I have to identify recession episodes and business cycles trough. The following tables present the mean across simulations for each statistics.

Again, since the results associated with the AR(2) and AR(1) forcing processes are very similar, I will show only results based upon simulations in which the AR(1) specification is employed.

Table 10-Contribution of Trade Balance to Output Growth(%)				
time after trough	Canada	$\rho = 0.5$	$\rho = 1.5$	$\rho = 3$
t+1	-0.17	-1.26	-0.96	-0.63
t+2	-0.22	-1.32	-1.06	-0.71
t+4	-1.08	-0.47	-0.45	-0.24
t+8	0.13	0.88	0.74	0.69
t+12	-0.69	1.22	0.91	1.01

Table 11-Contribution of Exports to Output Growth(%)				
time after trough	Canada	$\rho = 0.5$	$\rho = 1.5$	$\rho = 3$
t+1	0.52	-0.09	-0.14	-0.12
t+2	1.05	0.42	0.15	0.03
t+4	2.45	1.71	1.05	0.57
t+8	6.28	3.08	2.09	1.41
t+12	7.69	3.44	2.27	1.63

The instances of the model considered are able to generate negative contributions of trade balance at **t+1**, **t+2** and **t+4**. Overall, no specific parameterization is capable of generating a strong positive response of the contribution of exports.

4.4 The Role of Complementarity and Foreign Output Process

Based upon the three previous subsections, it is fair to say that complementarity plays a role in improving export-led recovery statistics. For an elasticity of substitution equal to 0.5, the contribution of exports is very close to zero at **t+1** and becomes positive and somewhat strong for the remaining horizons after a trough. The artificial economy with an elasticity of substitution equal to 3, regarding the contribution of exports, has a deplorable performance.

By contrast, a high elasticity of substitution seems to improve the impulse response of imports, as one can see by comparing figure three and four. The model faces the dilemma of being able to match the direction of all impulse responses at the expense of export-led recovery statistics and vice-versa, having a better performance in terms of export-led recovery statistics but paying the price of getting a wrong impulse response function for imports.

The exogenous stochastic process for foreign output has no role in generating better second moment statistics and is not relevant for export-led recovery statistics. However, the AR(2) specification seems to be important in generating impulse responses close to their empirical counterparts. This is not a surprise since the empirical impulse responses are coming from a set of second order bivariate VARs.

Summing up, it seems very difficult for the standard model to improve impulse response functions and export-led recovery statistics at the same time. Better performance in each arena requires a different type of elasticity of substitution. A high elasticity delivers better impulse responses and a low elasticity can generate improved export-led recovery statistics. The stochastic process for foreign output is only relevant in terms of generating shapes for impulse response functions which are compatible with the empirical ones.

5 The growing importance of vertical Specialization

This section borrows heavily from Hummels et al.(1998) and Hummels et al.(2000). These papers are empirical studies which measure vertical specialization and assess its importance in world trade. These works are, additionally, a radiography of world trade since data is taken at industry level and geographical factors, as well as country size, are taken into consideration.

In this section I will summarize some facts about the role of vertical specialization in modern trade .

My goal is to show that vertical specialization is a very important feature of trade and it is becoming more important over time. The point I want to make is that it is worth considering the impact of vertical specialization on business cycles since vertical specialization is a characteristic of modern trade which cannot be forgotten in any sensible analysis of trade dynamics and its effect on economic fluctuations .

Hummels et al. define vertical specialization more precisely. Three conditions must hold for vertical specialization to occur : (1) a good must be produced in multiple sequential stages; (2)two or more countries must specialize in producing some, but not all, stages and (3) at least one stage must cross an international border more than once.

The notion of vertical specialization involves an import and an export side. While intermediate goods trade is consistent with (1) and (2), only the subset of intermediate goods imports that become embodied in exports is able to meet the third condition. On the export side, vertical specialization can be associated with intermediate goods or final goods.

Put in other terms, vertical specialization occurs when a country uses imported intermediate parts to produce goods it later exports. This definition captures the idea that countries are linked in a chain of production.

The traditional notion of specialization is horizontal in which countries produce particular goods from scratch and then export them. Hummels et al. show that this traditional notion is becoming less important over time.

The first step, however, is to have a quantitative measure of the amount of trade due to vertical specialization.

The measure suggested is the following:

$$VS = \left(\frac{imported\ intermediates}{gross\ output}\right)\text{exports} \tag{16}$$

For technical details and possible pitfalls associated with the formula presented above, please consult Hummels et al.(1998,2000).

The measure can be operationalized as long as one is able to use informations contained in input-output tables . Input-output tables, like the OECD input-output database, include an *imported transactions* table for each country. Since these tables provide data on imported inputs, gross production and exports, one is able to compute the amount of vertical trade for a particular industry as well as for an entire country.

Basic results are :

- Vertical-specialization-based trade is increasing as a share of total output. Table 12 illustrates that claim. Japan is the only country where VS did not grow and for the US, VS is not very important. Furthermore, it is clear that VS is very important for small open industrialized economies.

Table 12-VS exports as a percentage of Merchandise Exports						
*	Australia		Canada		Denmark	
*	1968	1989	1971	1990	1972	1990
overall	9	11	20	27	29	29
chemicals	17	21	17	21	35	33
machinery	19	23	37	44	31	33
other	8	10	11	15	27	27

Table 12-continuation						
*	France		Germany		Japan	
*	1972	1990	1978	1990	1970	1990
overall	18	24	18	20	13	11
chemicals	21	27	24	24	12	18
machinery	18	25	15	17	10	9
other	17	22	22	22	18	16

Table 12-continuation						
*	Netherlands		UK		USA	
*	1972	1986	1968	1990	1972	1990
overall	34	37	20	26	6	11
chemicals	30	42	23	26	5	9
machinery	36	42	15	29	6	12
other	33	34	25	22	6	10

- Growth in vertical trade accounts on average for 25 percent or more of the growth in overall trade. Table number 13 summarizes that fact.

  The table shows, for each country, the growth rate in export share of output between the years highlighted in table one.

  In addition, the contribution of VS exports to growth in export share of output is displayed in the third column.

  It is worth noticing how important VS exports are for Canada. Hummels et al.(2000) also present the same table using emerging markets data. In fact, among developing economies, Mexico has the highest contribution of VS share.

These facts suggest the importance of VS for small economies, industrialized or not, which are extremely connected to the US economy.

Table 13-Contribution of VS to growth in export share of output		
country	export share of output(%)	contribution of VS share(%)
Australia	6	16.2
Canada	8	50.9
Denmark	17	30.8
France	11	32.4
Germany	9	22.2
Japan	3	6.1
Netherlands	10	48.2
UK	15	31.7
USA	7	14.1

- There is a positive relationship over time between vertical trade as a share of total trade and total trade as a share of gross merchandise output. To capture this relationship more accurately, Hummels et al. perform an OLS regression of total trade as a share of gross merchandise output on vertical trade as a share of total trade for all countries in their database. Country specific dummies were included to capture specific features of a particular country.

  I need to say that it is not possible to conclude that the growth in vertical trade is causing the growth in world trade. In spite of that, the regression indicates that both phenomena are tightly linked.

- The most common geographic pattern of vertical specialization involves North's imported inputs being transformed into exports goods destined for other North countries. Canada's vertical specialization is almost North-North.

It is imperative to remind the reader that tables and results in this section are a summary of the main conclusions in Hummels et al.(1998, 2000). More specifically, tables are abbreviated versions of a much more complete set of tables presented in the aforementioned papers.

6 A Model featuring Vertical-Specialization-based Trade

In proposing a model associated with vertical specialization, I stick to the definition in Hummels et al.(1998, 2000).

It is worth stating this definition once more.Hummels et al. define vertical specialization as follows.

Three conditions must hold for vertical specialization to occur : (1) a good must be produced in multiple sequential stages; (2)two or more countries must specialize in producing some, but not all, stages and (3) at least one stage must cross an international border more than once.

The notion of vertical specialization involves an import and an export side. While intermediate goods trade is consistent with (1) and (2), only the subset of intermediate goods imports that become embodied in exports is able to meet the third condition. On the export side, vertical specialization can be associated with intermediate goods or final goods.

The chain of production considered is a very simple one, characterized by two stages. The small open economy specializes in processing intermediate imports coming from the rest of the world, where the first stage takes place. This economy has two sectors, a final good sector and an export good sector. The final good sector as well as the export sector combine domestic intermediate inputs and foreign imported inputs in order to produce, respectively, the final good(to be domestically consumed) and an export good to be sold abroad. That structure is able to capture the elements in the definition of vertical specialization in a simple way.

Concerning export-led recoveries, the VS model has potential to account for that feature since exports react to positive external shocks and imports also increase. The VS model may be able to deliver figures able to match Prasad and Gable(1997) statistics for small open industrialized economies, which are characterized by a significant role of exports and a negligeable role of trade balance in driving the economy back to prosperity.

The story related to export-led recovery goes as follows.

After a positive external shock, the foreign demand for exports increases and the small open economy starts to export, but due to the VS structure it also starts to import a lot of intermediate inputs in order to meet the demand abroad. This is compatible with an increasing positive response of exports and imports, evolving pari passu over time, reaching the peak almost at the same time and starting a decline as the shock goes away.

The pattern described above is just the Canadian exports and imports impulse responses displayed in figure number two. Therefore, the VS model has also the potential to replicate Canadian trade dynamics.

6.1 The Building Blocks

6.1.1 Households

The representative household in the VS model solves the same problem described in the section discussing the standard small open RBC economy. Therefore, for the sake of brevity, I will not repeat most of the redundant equations.

The representative household maximizes the expected utility

$$U = E_0 \sum_{t=o}^{\infty} \beta^t u(C_t, L_t) \tag{17}$$

The budget constraint is :

$$p_t C_t + p_t I_t (1 + \frac{\psi}{2} (\frac{I_t}{K_t})) + b_{t+1} \leq r_t K_t + w_t N_t + (r_t^* - \theta b_t) b_t \tag{18}$$

6.1.2 Firms

The model is different from the standard model because here intermediate goods are used in the production of export goods.

- Final Good:

Firms engaged in the production of final goods maximize their profits, by solving the following optimization problem:

$$Max\{p_t V_t - pa_t A_v(t) - pd_t D_v(t)\} \tag{19}$$

subject to :

$$V_t = (w A_v(t)^\rho + (1 - w) D_v(t)^\rho)^{\frac{1}{\rho}} \tag{20}$$

The decision variables are: $A_v(t)$ and $D_v(t)$. Additionally, I have to consider the restriction $\rho < 1$.

The elasticity of substitution is defined as: $\epsilon l = \frac{1}{1-\rho}$.

$A_v(t)$ is a domestic intermediate input and $D_v(t)$ is an imported intermediate good.

- Country-Specific Intermediate Good:

Firms in the intermediate good sector maximize their profits and hire capital and labor to produce an intermediate good which can be used in the final good sector or in the export sector.

The amount of intermediate good used in the final good sector is $A_v(t)$ and the amount used in the export sector is $A_m(t)$.

The representative firm's problem is :

$$Max\{py_tY_t - r_tK_t - w_tN_t\} \tag{21}$$

subject to :

$$Y_t = Z_tN(t)^{\alpha}K(t)^{1-\alpha} \tag{22}$$

- Export Good

The export firm maximizes its profit. It uses domestic intermediate inputs $A_m(t)$ and imported intermediate $D_m(t)$.

The export firm optimization problem is :

$$Max\{p_xX_m(t) - pa_tA_m(t) - pd_tD_m(t)\} \tag{23}$$

The production function is :

$$X_m(t) = (w_mA_m(t)^{\rho_m} + (1-w_m)D_m(t)^{\rho_m})^{\frac{1}{\rho_m}} \tag{24}$$

The elasticity of substitution is defined as: $\epsilon l_m = \frac{1}{1-\rho_m}$

6.1.3 Additional Constraints and Export Demand Function

- Market Clearing Conditions are:

$$V_t = C_t + I_t \tag{25}$$

$$Y_t = A_v(t) + A_m(t) \tag{26}$$

- Export Demand Function:

$$X_m(t) = \alpha_0 Y_w(t) p_x^{-\alpha_x} \tag{27}$$

Notation: $Y_w(t)$ stands for the world output and p_x is the export price. α_0 is just a scale parameter and α_x denotes the price-elasticity of export (a positive number).

6.2 The Quantitative Exercise

The quantitative exercise involves a calibration stage, in which the basic parameters are assigned, and simulations.

The basic parameterization for the VS model incorporates complementarity, i.e., elasticities of substitution are set equal to 0.5.

The specification of the exogenous stochastic process is the same one used in the section discussing the standard small open economy model. The AR(2) specification is used most of the time. Sometimes, especially to compute second moments, the AR(1) specification is also employed.

I choose to include the AR(2) specification as well as complementarity since these features helped the model of the fourth section to perform better in two important dimensions: export-led recovery statistics and impulse responses.

Parameterization is summarized in the following table.

Table 14-Parameters:basic											
δ	ψ	α	θ	w	w_m	ϵl	ϵl_m	β	γ	α_x	α_0
0.1	0.75	0.68	10^{-6}	0.55	0.51	0.5	0.5	0.96	0.85	5	0.42

After the calibration stage is over, the first order conditions related to the model are linearized using an algorithm described in Christiano(1998). Linear policy rules are obtained. The policy rules enable me to simulate the model in order to compute second moments, impulse responses and export-led recovery statistics.

6.3 Results

6.3.1 Standard Business Cycle Statistics

HS stands for the standard open economy model(horizontal-specialization-based trade economy) with $\epsilon l = 0.5$.

The tables below summarize the performance of the models based upon their ability to replicate second moments associated with the data.

Table 15-Volatility				
Economy	$\sigma(Y)\ in\ \%$	$\frac{\sigma(C)}{\sigma(Y)}$	$\frac{\sigma(I)}{\sigma(Y)}$	$\frac{\sigma(N)}{\sigma(Y)}$
Canada	1.65	0.7	3.23	0.86
HS	1.67	0.37	3.53	0.36
VS	1.1	0.66	3.27	0.5

Table 16-Volatility-Trade Variables(%)				
Economy	$\sigma(\frac{\exp}{Y})$	$\sigma(\frac{imp}{Y})$	$\sigma(ToT)$	$\sigma(\frac{nx}{Y})$
Canada	3.90	4.31	2.39	0.8
HS	1.03	0.75	0.46	0.79
VS	0.95	0.71	0.45	1.03

Table 17-Correlation with Output			
Economy	C	I	N
Canada	0.77	0.78	0.82
HS	0.98	0.66	0.96
VS	0.77	0.81	0.98

Table 18-Correlation with Output-Trade Variables				
Economy	$\frac{\exp}{Y}$	$\frac{imp}{Y}$	TOT	$\frac{nx}{Y}$
Canada	0.43	0.53	0.02	-0.1
HS	0.32	-0.12	0.83	0.24
VS	0.71	0.47	0.5	0.88

The figures are based upon the AR(2) specification for the exogenous forcing process. The figures do not change much if one works with the AR(1) specification. Results associated with AR(1) process do not need to be presented for this reason.

The VS model generates less volatility for output. Exports, imports and terms of trade volatility are underestimated. Terms of trade and net exports remain procyclical. The big improvement concerns the correlation between output and exports as well as the correlation between output and imports. Figures for these variables are now positive in line with the data.

Overall, there is not much improvement in terms of second moments .

6.3.2 Impulse Responses

This section presents impulse responses related to the VS model. My goal is to compare the response of the model with the data. The idea here is to understand the transmission of shocks through variations in the terms of trade.

Impulse responses are computed assuming the AR(2) specification for foreign output.

Figure seven shows the response of GDP, terms of trade, exports as a fraction of GDP and imports as a fraction of GDP to a shock to US output. The terms of trade are defined as the relative price of imports in terms of exports .

All quantities go up on impact and start to converge back to their mean after approximately three quarters. GDP, exports and imports present a synchronized response to the foreign shock.

The magnitudes of exports and imports are very similar, though exports seem to respond more strongly to the foreign shock. This is not entirely compatible with the empirical impulse response. But, the impulse responses associated with trade variables are much closer to the empirical ones than any impulse responses generated by the standard open economy model without vertical-specialization-based trade.

In the figure the terms of trade do not respond strongly and go down on impact. However, such behavior is still in line with the empirical impulse response in figure two, since the impulse response delivered by the model is within the confidence interval bands..

The VS model performs better since it is able to predict the direction of the impulse response correctly for all trade variables considered. Additionally, the model generates impulse response functions which are close to their empirical counterparts in magnitude.

6.3.3 Export-Led Recovery Statistics

HS stands for the standard open economy model(horizontal-specialization-based trade economy) with $\epsilon l = 0.5$. VS stands for vertical-specialization-based trade model. In both models, I use the AR(2) specification for the exogenous stochastic shocks.

The methodology described in section three is applied to artificial data generated by the HS and VS models. These models are simulated 500 times.

For each simulation, I have to identify recession episodes and business cycles trough. The following tables present the mean across simulations for each statistics.

Table 19-Contribution of Trade Balance to Output Growth(%)			
time after trough	Canada	HS	VS
t+1	-0.17	-1.25	-0.85
t+2	-0.22	-1.35	-0.48
t+4	-1.08	-0.33	0.74
t+8	0.13	1.01	2.1
t+12	-0.69	1.18	2.3

Table 20-Contribution of Exports to Output Growth(%)			
time after trough	Canada	HS	VS
t+1	0.52	-0.11	0.11
t+2	1.05	0.45	1.69
t+4	2.45	1.84	5.18
t+8	6.28	3.21	8.62
t+12	7.69	3.33	9.15

Qualitatively, the VS model is able to explain export-led recoveries more accurately. The contribution of exports is always positive and increasing as it is in the data. The magnitude of the contribution of exports is much stronger in the VS model. The VS model generates negative contribution of trade balance only at **t+1** and **t+2**. Therefore, trade balance does not respond positively after a trough, which is somewhat in line with the data. In spite of that, the HS model is able to generate a negative contributions of trade balance at **t+1**, **t+2** and **t+4**.

This fact suggests that a better description of export-led recoveries cannot be forged without considering both trade patterns. I do not interpret this as a weakness of the VS model since the empirical pattern for the contribution of trade balance in economic recovery episodes is not very clear as it is easy to see in section two. The robust empirical regularity is that the contribution of exports is always positive and increasing over the time horizon after a trough. In this regard, the VS model performs better than the HS model.

7 Conclusion

This paper compares two small open economy macro models based upon different trade patterns. I consider two trade patterns, vertical specialization and horizontal specialization. A vertically specialized(VS) economy is characterized by being part of a chain of production which stretches across countries, therefore export firms buy imports and use them to produce goods which will be exported later. On the other hand, horizontal specialization(HS) is a trade pattern in which countries trade goods that are produced from start to finish in just one country.

There are empirical studies which point to the increasing importance of vertical specialization for international trade, especially for small open developed economies. Based on that observation, I believe it is worth assessing the implications of vertical specialization for the propagation of business cycles in the context of a small open RBC model, paying special attention to export-led recovery episodes.

I compare my two models according to the following metrics: business cycles second moments, the response of trade variables to a shock in the world GNP and the role of trade balance and exports in economic recoveries

My basic conclusions are:

- a standard open economy model without VS cannot generate at the same time impulse response functions and export-led recovery statistics compatible with the data.

- the AR(2) specification improves the shape of impulse response functions in a standard small open economy model.

- the VS model which incorporates complementarity and the AR(2) specification is able to generate contribution of exports and impulse responses close to their empirical counterparts. However, second moment statistics and the contribution of trade balance are not as compatible with the data as they should be.

In short, VS structure, complementarity and the AR(2) specification seem to be important ingredients associated with export-led recovery episodes.

The models studied in this paper have limitations that need to be discussed. First, they do not address different channels of propagation such as foreign interest rate or working capital associated with imports. This is intentional since my focus was on trade.

Second, the models are idealized versions in the sense that there is no mix of trade patterns. Of course, in real economies, just a fraction of exports are vertically integrated.

Third, the chain of production described is a very simple one. The small open economy buys imports and uses them to produce exports shipped back to the rest of the world. So, I consider a two stage chain of production.

Huang and Liu(2000) consider a monetary two-country model with sticky prices and a multi-stage chain of production to address some international business cycle puzzles. Their structure can be adapted to a non-monetary world in which the two countries have different sizes and the same questions addressed in my paper can be asked. A future project may consider the importance of the number of stages in the vertically integrated chain as a robustness check to the results presented here.

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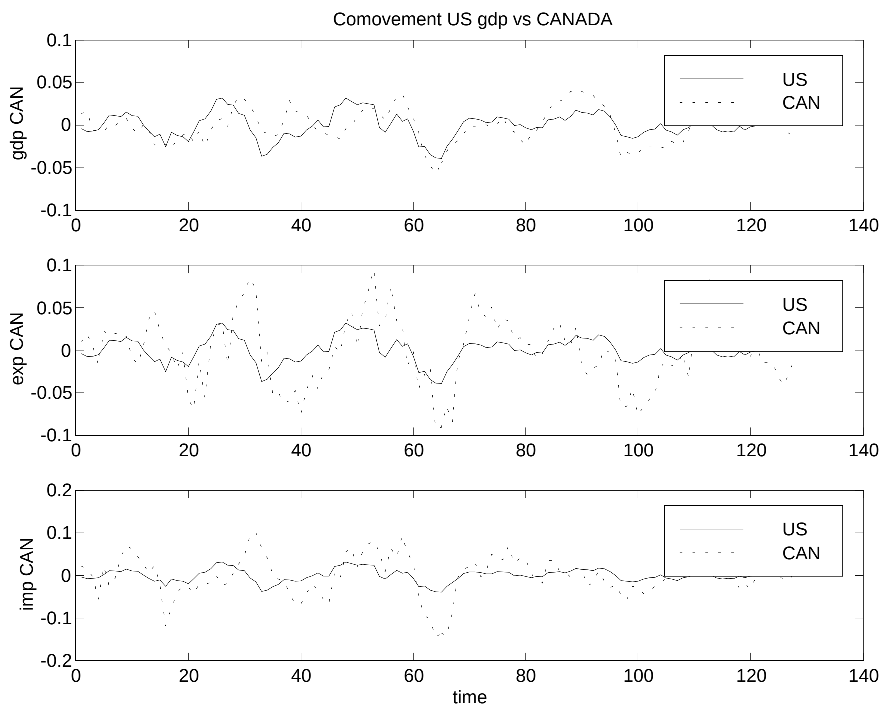

Figure 1: Comovement: CA vs. US

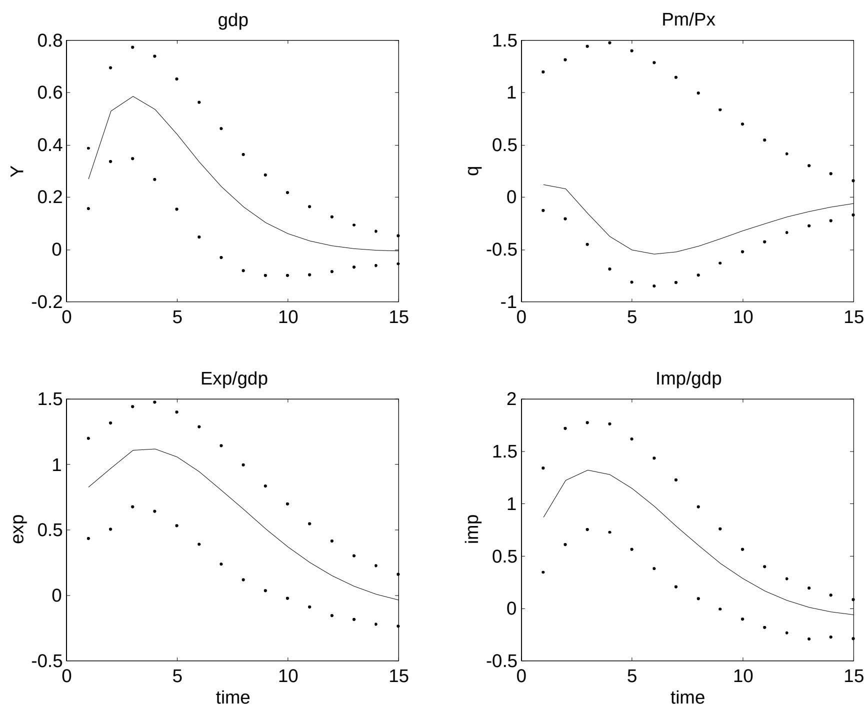

Figure 2: Empirical Impulse Responses

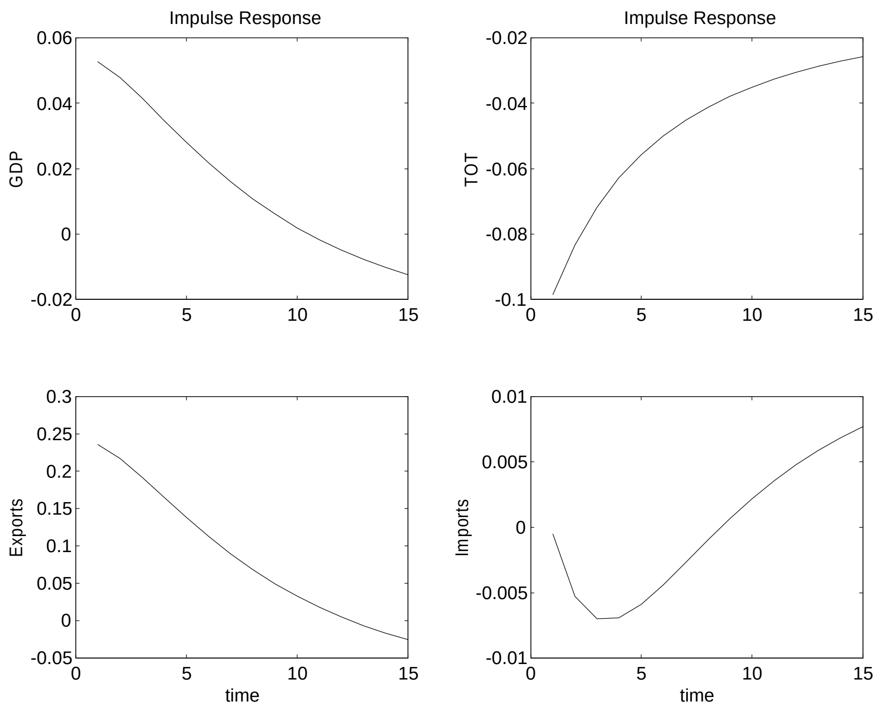

Figure 3: HS: AR(1) and elasticity = 1.5

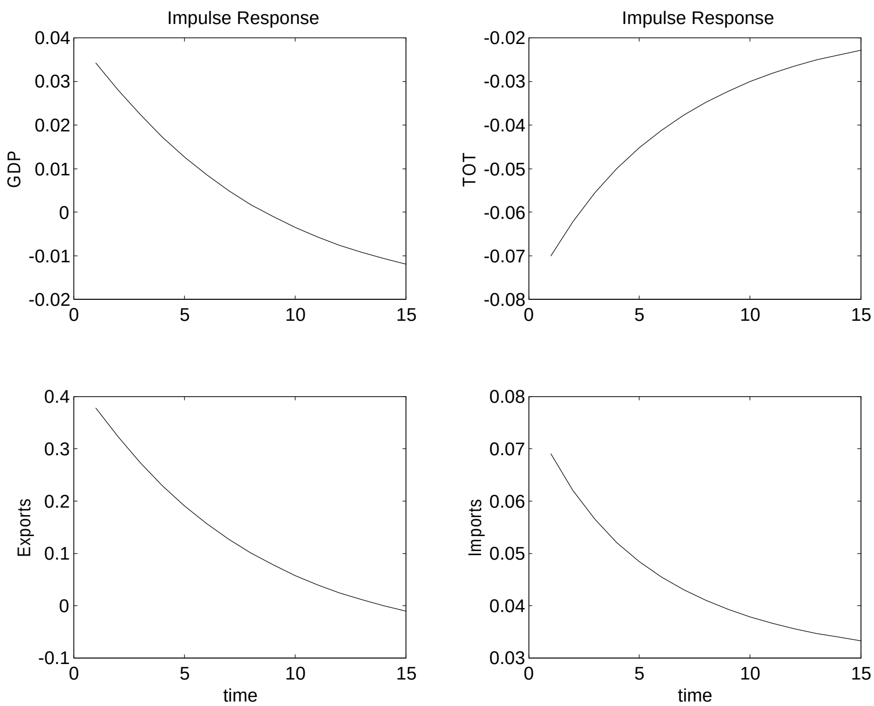

Figure 4: HS: AR(1) and elasticity = 3

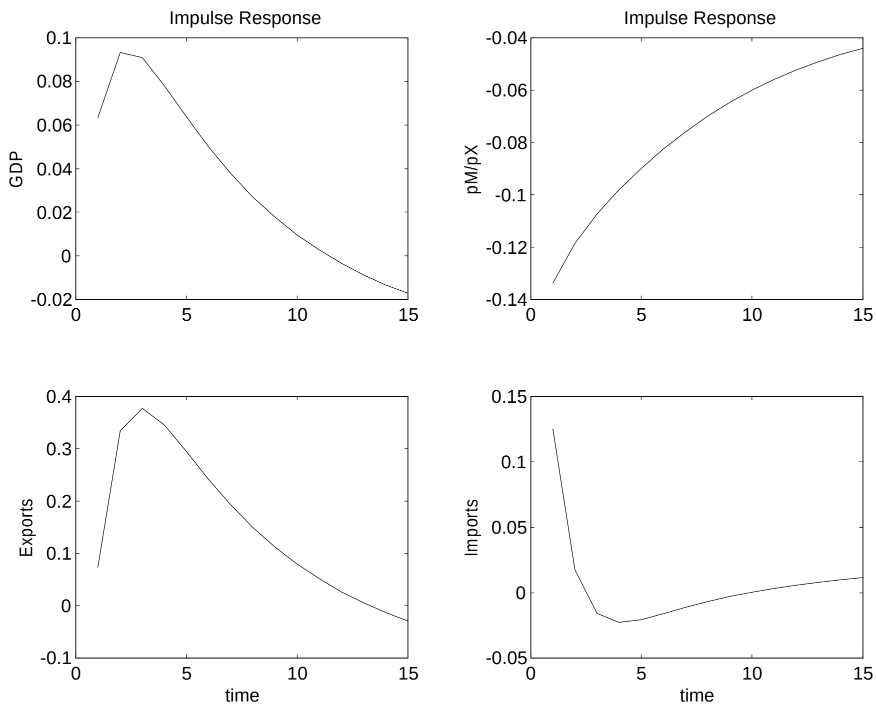

Figure 5: HS: AR(2) and elasticity = 1.5

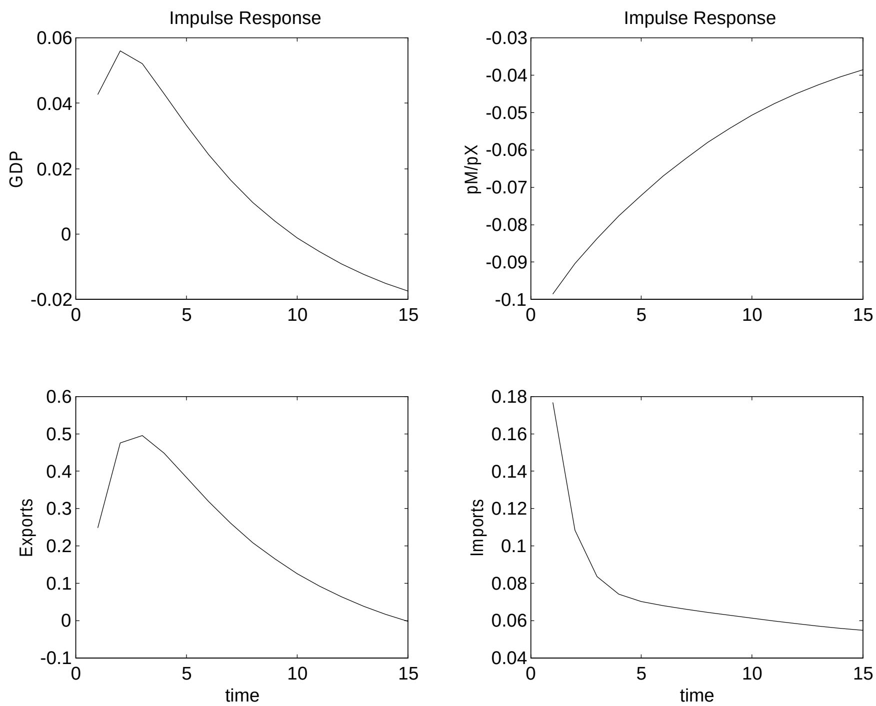

Figure 6: HS: AR(2) and elasticity = 3

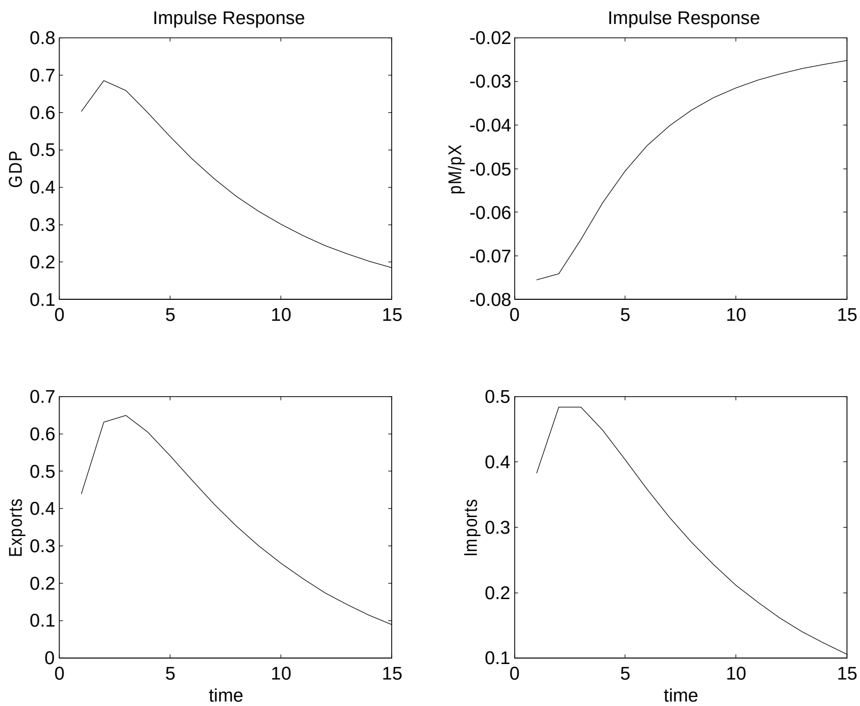

Figure 7: VS: AR(2) and elasticities = 0.5