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International Real Business Cycles among Heterogeneous Countries

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Abstract

Business cycle statistics differ widely across countries for some aggregates, especially for trade-related variables. Part of these variations relates to the size of the economies and to their distance from each other. This paper asks whether a three-country model is able to display the marked diversity of business cycle statistics observed across countries. The model is calibrated to two specific examples, Canada and Switzerland. Our findings are that most of the diversity of the business cycles can be accounted for by size and distance, and that trade is not a strong channel of diffusion of cycles.

Résumé

Les statistiques du cycle conjoncturel varient fortement d'un pays à un autre, spécialement pour les variables liées au commerce. Cette variété dépend en partie de la taille des économies et de leurs distances respectives. Ce papier étudie si un modèle à trois pays est capable de générer parmi ces pays la diversité des statistiques du cycle observée. Le modèle est calibré à deux exemples, le Canada et la Suisse. Nous trouvons que la majeure partie de la diversité du cycle conjoncturel provient de la taille et de la distance et que le commerce n'est pas un canal important de la diffusion des cycles.

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1 Introduction

Properties of business cycles and dynamic models representing them have been extensively studied since the seminal papers of Kydland & Prescott (1982) and Long & Plosser (1983). So far, an overwhelming part of this literature has concentrated on closed-economy aspects, and has focussed primarily on the United States. Business cycle models with open economies are rather new, and deal usually with symmetric countries.[1] But various data surveys[2] show that the business cycle behavior exhibits diversity across countries for some series, especially for trade related variables. Also, the magnitude of the cycles varies from one country to another. Typically, smaller countries exhibit higher volatility of their economic aggregates (see also Gerlach (1988) and Head (1995)). Furthermore, the relative volume of their trade usually is larger, which may lead to a larger influence of foreign business cycles on their own.

This paper explores whether the diversity observed in the data can be accounted for by an international real business cycle model with technology shocks alone. Three countries are considered in the model, a small country with a large neighbor and the distant (and large) rest of the World. This prevents symmetry constraints for comovements between any two countries. Also, this permits dealing with the fact that a small economy is usually more related to its large neighbor than to the rest of the World. The model is applied to two small countries, Canada and Switzerland. We ask whether a simple real business cycle model with technology shocks can replicate the observed comovements and relative volatilities of economic aggregates for large and small countries. Then, we evaluate numerically what the primary channels of diffusion of shocks are and explore what characteristics are linked to the size of the countries.

We find that size and distance can indeed account for the diversity in the observed business cycles in those examples. The statistics are robust to alternative parameter values, except for the elasticity of substitution between goods. The diversity of the statistics is, however, maintained for any reasonable value of this elasticity. We find also that small countries are indeed more sensitive to foreign technology innovations. Moreover, the business cycle is transmitted mostly through innovation spillovers rather than through trade. Furthermore, the volatility of innovations is higher in small countries. Alternative specifications of the model show that introducing delivery lags increases the volatility of the terms of trade and shifts the J-curves.

The observed high volatility of the international variables (exports, imports, trade balance, terms of trade) is, however, not attained. This calls for the inclusion of additional shocks, such as exchange rate fluctuations.[3] Also, the predicted cross-correlations of output levels are

[1]Some examples are Dellas (1986), Cantor & Mark (1987, 1988), and Canova & Dellas (1990) with qualitative results, Backus, Kehoe, & Kydland (1992, 1994), as well as Baxter & Crucini (1993) and Stockman & Tesar (1995) with numerical simulations.

[2]Such as Backus & Kehoe (1992), Baxter & Stockman (1989), Danthine & Girardin (1989), Entorf (1991), Backus et al. (1992, 1994), Fiorito & Kollintzas (1994) and Zimmermann (1995).

[3]See Zimmermann (1994a).

much lower than those of consumption. Indeed, data exhibit more often output smoothing than consumption smoothing.

The remainder of the paper is structured as follows. Section 2 describes business cycle statistics in two three-country partitions. The model economy is formulated in Section 3. Section 4 presents the computation of steady state equilibria and the calibration. Section 5 gives an overview of the method used for the calculation of histories. Section 6 lays out the business cycle properties of the experimental economies. In Section 7, we perform some sensitivity analysis on the model's parameters. In Section 8, the origin of the specificities of small and / or distant countries is examined. Section 9 draws some conclusions and suggests topics for future research. An appendix gives the sources of the data.

2 Business Cycle Properties of the Data

Business cycles are not the same from one country to the other, although they are quite similar along certain dimensions. This section summarizes some of the most salient properties of business cycles by looking at comovements. These "stylized facts" are drawn from two partitions of the industrialized world (Figure 1): the first considers Switzerland as the small country, the rest of Europe, called Europe(-), as the large neighbor, and a composite of North America and Japan as the rest of the World (ROW1). The second partition includes Canada, its neighbor, the United States, and the rest of the World (ROW2), a composite of Europe and Japan. An appendix describes the aggregation procedure and the data sources.

We summarize the business cycle properties of these economies in the form of comovements of HP-filtered data [Hodrick & Prescott (1980)]. Standard deviations of cyclical components indicate how volatile several aggregates are. Autocorrelations show how persistent they are. Correlation coefficients with output provide a picture of how procyclical these aggregates are. Cross-correlations show how the same aggregates move together across countries. In Tables 1 and 2, such statistics are provided for a 100-quarter sample from 1965.I to 1989.IV.

A correlation of special interest is that between the trade balance and the terms of trade (the ratio of import prices to export prices). Traditionally, open economy macroeconomists have been interested in the response of the trade balance to shocks on the terms of trade (especially the exchange rate) in the short and long run. This is the so-called J-curve, that is an improvement in terms of trade first leads to a trade deficit, followed by a surplus in the longer term. In a stochastic framework with endogenous prices, this is measured through correlations between these two variables. Looking at leads and lags, the correlations often form a picture very similar to the textbook J-curve. These are presented in Figure 2.

With the help of these statistics, we can establish in which respects the economies studied here are similar, and in which they differ. For the latter, some facts could be categorized according to the size of the economy, other according to their vicinity to each other. The simulations of model economies will provide answers as to whether such facts can be replicated.

First, we take a look at the similarities in Table 1. In all countries, we have a similar pattern of volatility across aggregates: investment is two or three times as volatile as output, whereas the standard deviation of total consumption (which includes consumer durables) is around 80% that of output, similarly to employment; exports and imports are the most volatile, where imports have roughly the same standard deviations across countries.

Looking at the autocorrelations, we see that the persistence of consumption is smaller than that of any other aggregate in all countries. From the correlations, we observe that all the aggregates we consider are procyclical, with the exception of the trade balance and the terms of trade. Exports have a relatively low correlation with the business cycle. From Figure 2, we learn that the correlations of the trade balance with the terms of trade at various leads and lags exhibit, indeed, the J-curve pattern: the terms of trade are negatively correlated with past trade balances but positively correlated with future ones. Finally, cross-correlations of output are always higher than those of consumption.

Second, categorizing Switzerland and Canada as small countries and all others as large, the business cycle statistics reveal some striking differences: The volatility of most aggregates is higher in the small countries. This is the most noticeable with the trade balance.[4] There are exceptions, for example the terms of trade tend to be more volatile in large countries. Furthermore, the United States often do not fit the image of a large country with respect to volatility.[5]

Persistence of all variables is lower in Switzerland, but this is not obvious for Canada. Consumption appears to be more procyclical in the large countries. Trade aggregates are, however, more procyclical (imports and exports, countercyclical for the trade balance) in the small countries.

Third, we distinguish between neighboring and distant country pairs: Switzerland and Europe(-) are neighbors, Canada and the United States are, too. Looking at cross-correlations, they are higher between a small country and its neighbors than between the small country and the rest of the World.

3 The Model Economy

The following model lies within the class of dynamic general equilibrium models introduced by Backus et al. (1994). To reflect the heterogeneities mentioned in the introduction, we build a model economy with three countries, each populated by representative agents. Each maximizes utility and has access to a production function identical to all members of a country. These representative agents live forever and their labor force is immobile across

[4]Size and openness of the economy have clearly a strong effect on this statistic, as it is unit dependent and small countries have larger import and export shares. It should be noted that the data used here excludes internal trade (trade among European countries for example), where we assumed that internal trade has the same cyclical properties as external trade. Not removing this internal trade yields larger net trade volatilities for the entities composed of several countries: 0.56 for Europe(-), 0.29 for ROW1, 0.57 for ROW2.

[5]For additional analysis regarding this evidence, see Zimmermann (1994b).

countries. The goods are traded across countries without restrictions. The number of agents defines the size of the economy. All variables of the model are defined in own-country per capita terms.

Each agent maximizes his expected utility represented by a function of the form:

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t U(c_{it}, 1 - n_{it}) \right], \tag{1}$$

where

$U(c_{it}, 1 - n_{it}) = \left[c_{it}^{\mu} (1 - n_{it})^{1-\mu} \right]^{\gamma} / \gamma$,
c_{it} is consumption in country i at time t,
n_{it} is the share of time devoted to market activities in country i at time t,
and $0 < \beta < 1, 0 < \mu < 1, \gamma < 1$.

Note that for $\gamma = 0$, we have logarithmic utility:

$$U(c_{it}, 1 - n_{it}) = \mu \log(c_{it}) + (1 - \mu) \log(1 - n_{it}).$$

Each country i produces one good, y_{it}, with capital k_{it} and labor n_{it}. The production function $F(\cdot)$ is Cobb-Douglas, with a stochastic technology parameter z_{it}, whose law of motion will be described later:

$$y_{it} = z_{it} F(k_{it}, n_{it}), \tag{2}$$

where

$$F(k_{it}, n_{it}) = k_{it}^{\theta} n_{it}^{1-\theta}, \quad 0 < \theta < 1$$

The output is used domestically and exported. We define y_{ijt} to be the amount of goods per inhabitant of country j used in j and produced in country i. Next, define α_i as the number of households in country i. Then, for any country i, its total production is used at home, y_{iit}, and abroad, y_{ijt} in country j and y_{ikt} in country k:

$$\alpha_i y_{it} = \alpha_i y_{iit} + \alpha_j y_{ijt} + \alpha_k y_{ikt}, \quad i \neq j \neq k \tag{3}$$

Imports and domestic production are used for consumption c_{it} and investment x_{it}. In order to take into account the finite elasticity of substitution between goods of different origins, an Armington (1969) aggregator $G(\cdot)$ is used. This function allows for cross-hauling (importing while at the same time exporting), by attaching a label of origin to the goods, and introduces imperfect substitution between the labeled goods. A country then specializes in the production of the *home* good, but uses three different goods for consumption and investment. The Armington aggregator is widely used in the international economics literature, although it relies on elasticities difficult to assess:

$$c_{it} + x_{it} = G(y_{iit}, y_{jit}, y_{kit}), \tag{4}$$

where

$$G(y_{iit}, y_{jit}, y_{kit}) = \left(\omega_{iit} y_{iit}^{-\rho} + \omega_{jit} y_{jit}^{-\rho} + \omega_{kit} y_{kit}^{-\rho}\right)^{-1/\rho}, \quad \omega_{ii}, \omega_{ji}, \omega_{ki} \geq 0, \quad \rho \geq -1. \tag{5}$$

The elasticity of substitution is then $\sigma = \frac{1}{1+\rho}$. Note that σ is the same between domestic and imported goods as between two imported goods. Nesting the Armington aggregator to differentiate these elasticities makes the calibration much more difficult. The law of motion of the capital stock is:

$$k_{i,t+1} = (1 - \delta) k_{it} + x_{it}, \tag{6}$$

where $0 < \delta < 1$ is the depreciation rate.

The country-specific technology parameter follows a Markov process and is driven by its lagged value in all countries and by serially independent, contemporaneously correlated innovations ε_{t+1}. Such an AR(1) structure is appropriate as the data show high persistence of technological shocks. Also, it allows one to account for spillover effects across countries:

$$z_{t+1} = \overline{z} + A(L) z_t + B(L) \varepsilon_{t+1}, \tag{7}$$

where

$$z_t = \begin{pmatrix} z_{1t} \\ z_{2t} \\ z_{3t} \end{pmatrix},$$

$$\varepsilon_{t+1} = \begin{pmatrix} \varepsilon_{1,t+1} \\ \varepsilon_{2,t+1} \\ \varepsilon_{3,t+1} \end{pmatrix},$$

$$A(L) = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix},$$

$$B(L) = \begin{pmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{pmatrix},$$

$$\varepsilon_{t+1} \rightsquigarrow \mathcal{N}\left(\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}, \begin{bmatrix} v_{11} & v_{21} & v_{31} \\ v_{21} & v_{22} & v_{32} \\ v_{31} & v_{32} & v_{33} \end{bmatrix} \right).$$

This closes the model. It allows for several types of heterogeneities:

- $y_{iit} \neq y_{jjt}$: The difference in the share of domestic goods to total output implies that the countries are populated by a different number of agents. To maintain a zero trade balance, small countries need a higher share of imported goods than larger countries;

- $\alpha_j y_{ijt} \neq \alpha_i y_{jit}$: This implies that there are some asymmetries in the preferences. As we have a zero trade balance in the steady state, this must be compensated by asymmetries with the third country;

- $a_{ii} \neq a_{jj}$: This heterogeneity is also related to the size, as a smaller country will have a smaller persistence of the technological shock. The structure of the diffusion of these innovations can however be different from the trade structure;

- $a_{ij} \neq a_{ji}$: Asymmetries in the international spillovers can also reflect size. A small country may more easily take benefit of an innovation in a large country than the reverse;

- $a_{ij} \neq a_{ik}$: Spillovers depend on the level of interrelations between the countries;

- $v_{ij} \neq v_{ik}$: As above, shocks may be more highly correlated between some countries than others. The distance (integration of economies) may play a role here;

- $v_{ii} \neq v_{jj}$: The variance of shocks may be lower in a country, for example due to the better diversification of a large economy. Having many industries, each subject to specific, not perfectly correlated shocks, leads to a lower volatility than an identical economy but with fewer industries, see Horvath (1994).

4 Steady State and Calibration

The steady-state competitive equilibrium of the model above is such that the prices for factors and goods clear all markets and all trade balances are zero. As the price and commodity spaces are convex and the production and utility functions are strictly concave, the equilibrium is unique. In the steady state, the producer's problem in each country i is:

$$\max_{\{k_i,n_i\}} z_i k_i^{\theta} n_i^{1-\theta} - w_i n_i - (r+\delta)k_i, \tag{8}$$

where w_i is the wage. From the first order conditions, it is easy to establish that:

$$k_i = \frac{\theta y_i}{r+\delta},$$

implying

$$x_i = \frac{\delta\theta y_i}{r+\delta},$$

$$w_i = (1-\theta)\frac{y_i}{n_i}.$$

The consumer's problem is:

$$\begin{array}{ll} \max_{\{c_i,n_i\}} & \left[c_i^{\mu}(1-n_i)^{1-\mu}\right]^{\gamma}/\gamma \\ \text{S.T.} & w_i n_i + (r+\delta)k_i = c_i + \delta k_i. \end{array} \tag{9}$$

This implies:

$$w_i = \frac{c_i}{1-n_i}\frac{1-\mu}{\mu},$$

so that

$$c_i = (1-\theta)y_i\frac{1-n_i}{n_i}\frac{\mu}{1-\mu}.$$

Using the household's budget constraint, we obtain:

$$n_i = \frac{(1-\theta)\frac{\mu}{1-\mu}}{1+(1-\theta)\frac{\mu}{1-\mu}-\frac{\delta\theta}{r+\delta}}.$$

Inserting the Armington aggregator into the household's problem and maximizing over the three goods, one can solve for the terms of trade, the ratio of the price of imports to the price of domestic goods. For each pair of countries, we have:

$$\begin{aligned} p_{ijt} &= \frac{\frac{\partial G(y_{iit},y_{jit},y_{kit})}{\partial y_{jit}}}{\frac{\partial G(y_{iit},y_{jit},y_{kit})}{\partial y_{iit}}} \\ &= \frac{\omega_{jit}}{\omega_{iit}}\left(\frac{y_{iit}}{y_{jit}}\right)^{\rho+1}. \end{aligned}$$

For each country, the aggregate terms of trade are then defined by:

$$p_{it} = \frac{y_{jit}p_{ijt} + y_{kit}p_{ikt}}{y_{jit} + y_{kit}}. \tag{10}$$

In the steady state, the terms of trade are equal to one. Using this fact and the equilibrium of the trade balance, one can infer the equilibria for y_{iit}, y_{jit} and y_{kit}:

$$\begin{aligned}
y_{iit} &= \frac{y_{it}}{1 + \left(\frac{\omega_{ji}}{\omega_{ii}}\right)^{\frac{1}{\rho+1}} + \left(\frac{\omega_{ki}}{\omega_{ii}}\right)^{\frac{1}{\rho+1}}}, \\
y_{jit} &= \frac{y_{it}}{1 + \left(\frac{\omega_{ii}}{\omega_{ji}}\right)^{\frac{1}{\rho+1}} + \left(\frac{\omega_{ki}}{\omega_{ji}}\right)^{\frac{1}{\rho+1}}}, \\
y_{kit} &= \frac{y_{it}}{1 + \left(\frac{\omega_{ii}}{\omega_{ki}}\right)^{\frac{1}{\rho+1}} + \left(\frac{\omega_{ji}}{\omega_{ki}}\right)^{\frac{1}{\rho+1}}}.
\end{aligned}$$

Finally, we define the trade balance by:

$$nx_{it} = y_{ijt} + y_{ikt} - p_{it}(y_{jit} + y_{kit}).$$

The procedure for calibrating the parameters of the above model is identical to Kydland & Prescott (1982), except for the parameters relative to its international part. We can therefore easily compare our results to Backus et al. (1994). Following the strategy widely used for real business cycle studies, most of the parameters are chosen to match empirical results from microeconomic studies or long-term averages. So we set $r = \frac{1}{\beta} - 1 = 0.01$ and $\delta = 0.025$ per quarter.

From the equilibrium above, it can be shown that θ corresponds, in the steady state, to the share of capital income to total income, $\theta = (r + \delta)\frac{k}{y}$. We set the capital stocks, on average, to 10 quarters of output, so that $\theta = 0.35$. Also, μ is determined by the expression:

$$\mu = \frac{1}{1 + (1 - \theta)\frac{1-n}{n}\frac{y}{c}},$$

where we choose $n = 0.3$ and where $\frac{c}{y} = 0.75$. Finally, the curvature of the utility function, γ, is fixed at -1. This is rather arbitrary and we will experiment with other values.

Note that all these parameter values are widely used in real business cycle models of the United States economy. We leave to future research the possibility that these may be different for other economies, and apply these values to all three countries of our model.

To determine the nine ω_{ij}'s in the Armington aggregator, we first determine the steady-state y_{ij}'s to match the average import shares from the data. Then we choose the ω_{ij}'s such that each of the Armington aggregators sums up to the level of output (homogeneity of degree one, three equations), and such that the terms of trade p_{ij} are unity in the steady state (six equations). We get then:

$$\omega_{ji} = \left(\frac{y_{ji}}{y_i}\right)^{\rho+1}, \quad i,j \in \{1,2,3\}.$$

Finally, we let the elasticity of substitution among goods be $\sigma = \frac{1}{1+\rho} = 1.5$, as used by Backus et al. (1994). This value is a *best guess* from Whalley (1985), but is subject to discussion, as such elasticities are not well established. Zimmermann (1994b) suggests that this elasticity should be higher. Considering, however, the uncertainty associated with his estimated values, we keep here the value of 1.5 traditionally used, but we will use alternative values in the sensitivity analysis of Section 7.

The appendix describes the data used to determine the import shares. The latter are shown in Table 3 for the two partitions we will consider. Assuming that there is a zero trade balance in all countries, it is possible to determine the implicit size of the countries. The difference with the actual sizes comes from nonzero average trade balance over the sample period and from the fact that per capita output is not equal across countries as assumed in the model, although the countries considered are of a similar level of development.

For the laws of motion of the technology shocks, we first put $B(L)$ equal to the identity matrix. Indeed, cross-correlations of the fundamental innovations are already accounted for by the matrix V. The spillovers of the technology shocks are estimated with Solow residuals, calculated with the calibrated capital income share, as well as real output and employment series. We regress the technology level on past values across the countries, hereby finding the matrix A. Finally, instantaneous correlations and standard deviations of the regression residuals are used for the covariance matrix V.

The Solow residuals are positively correlated to each other, but less than output levels. We see that the shocks to the technology level are more variable in the small country. Also, their correlations are higher between neighbors than between distant countries. Furthermore, the domestic spillover coefficients are clearly lower for the small countries, hereby reflecting their openness. The eigenvalues of the matrix A are 0.730, 0.912 and 0.9991 in the first partition and 0.772, 0.932 and 1.0009 in the second one. Having an eigenvalue over one could induce dynamic unstability. Although this did not happen in any of our simulations, we "bump" the values of the diagonal by lowering them by 0.001 points in the second partition. The new eigenvalues are then 0.771, 0.931 and 0.99990, and the calibrated model is dynamically stable. Finally, the standard deviations for the large countries are in line with other estimates in the literature. Note that the AR(1) assumption for the technological process is consistent with the data, except for Switzerland where the residuals show some autocorrelation, although not significant at the 10% level.[6]

[6] Replications with autocorrelated shocks do not give different results.

Two points call for attention. The first concerns the negative coefficients for the spillover effects between Switzerland and ROW1. We cannot rule out that they are positive, as both of them are within one-half standard deviation from zero. But we can justify negative spillover effects in certain situations: a positive technology shock in a country gives it a competitive advantage against the others, whose output, and therefore productivity, decreases while losing market shares. Such a phenomenon could be observed as Japanese manufacturers introduced the quartz movement to the detriment of the Swiss watch industry.[7]

A second point of interest deals with the intertemporal stability of our results. We computed the same regression on a shorter sample (70.I to 89.IV) in order to include quarterly data for more European countries. While the results were essentially the same with or without these additional countries, we got quite different spillover effects compared to the longer sample. Specifically, all domestic spillovers are smaller, foreign spillovers move both ways, standard deviations are not significantly different, and most of the correlations are higher. These differences may be explained by the fact that trade increased more rapidly than output during the period considered. Also, the strong oil shocks have more weight in a shorter sample and lead to higher estimates of international comovements. Finally, the exchange rate regime might also influence our estimates, as Gerlach (1988) suggests for the volatility of output. We stress therefore that the estimates of Table 4 are those obtained for the entire period from 65.I to 89.IV.

5 Computation of Histories

To compute equilibrium decision rules, we use the method pioneered by Kydland & Prescott (1982), and, for the computational procedure, explained in Hansen & Prescott (1995). In this section, we give an overview, and present some details relevant to this model.

The aim is to determine decision rules for the set of decision variables (labor, investment, imports) as functions of a given set of state variables (capital and technology). In infinite horizon problems, it is possible to solve this analytically for particular functional forms, as in Long & Plosser (1983) or Hercowitz & Sampson (1991), but these models are not very realistic, as Plosser (1991) argues. Our model is calibrated so that decision rules can be computed numerically using dynamic programming techniques.

The economy considered here has no externalities such as distorting taxes. Also, this is a well-behaved concave problem with local nonsatiation. We can therefore apply the Second Welfare Theorem and analyze the problem in terms of a social planner maximizing a weighted sum of the representative agents' utilities, where the weights are such that output is on average equal to consumption plus investment (zero trade balance) for each agent. The steady state version of this problem satisfies:

[7]Putting to zero off-diagonal elements of A that are negative or not significantly different from zero does not change the results except for consumption, which becomes unrealistically smooth and procyclical.

$$\max_{\{n_{it},c_{it},k_{i,t+1}\}} \quad \sum_{t=0}^{\infty}\beta^t \sum_{i\in\{1,2,3\}} \alpha_i \left[c_{it}^{\mu}\left(1-n_{it}\right)^{1-\mu}\right]^{\gamma}/\gamma$$
$$\text{S.T.} \quad c_{it}+k_{i,t+1}-(1-\delta)k_{it}=z_{it}k_{it}^{\theta}n_{it}^{1-\theta} \quad \forall i.$$

It is easy to show that, predictably, the steady-state equilibrium for this problem is identical to the competitive equilibrium of Section 4 if the α_i correspond to the size of the countries. As the model is formulated in per capita terms, this is equivalent to maximizing the sum of the utilities of all agents. The computational experiments make use of this last equilibrium.

Solving for the decision rules as the model stands now is computationally very costly because there are nonlinear difference equations. So we make a Taylor expansion of second order of the global utility function around steady-state values. This global utility function is obtained by substituting (2)–(4) into (1):

$$\sum_{t=0}^{\infty}\beta^t \sum_{i\in\{1,2,3\}} \alpha_i U(G[z_{it}F(k_{it},n_{it})-\frac{\alpha_j}{\alpha_i}y_{ijt}-\frac{\alpha_k}{\alpha_i}y_{ikt},y_{jit},y_{kit}]-x_{it},1-n_{it}) \quad (11)$$
$$\text{S.T.} \quad k_{i,t+1}=(1-\delta)k_{it}+x_{it} \quad \forall i\in\{1,2,3\}, \quad (5)$$
$$z_{t+1}=\overline{z}+A(L)z_t+B(L)\varepsilon_{t+1}, \quad (6)$$
$$\text{with} \quad j,k\in\{1,2,3\}, \quad j\neq i, \quad k\neq i.$$

The utility function (11) is approximated with respect to (z_{it}, k_{it}, n_{it}, y_{jit}, y_{kit}, x_{it}, $\forall i|i\neq j,k$). With this quadratic approximation of a utility function and the linear constraints (5) and (6), we compute iteratively the valuation function, also quadratic, and the linear decision rules. In the basic model, we obtain the decision variables n_{it}, y_{ijt} and x_{it} as functions of the state variables k_{jt} and z_{jt} for $i,j\in\{1,2,3\}$.

We then run 200 histories with 100 periods each, introducing random shocks to the technology parameter $z_{i,t+1}$. The other variables are then updated through the laws of motion ($k_{i,t+1}$), the decision rules (n_{it}, y_{ijt}, y_{ikt}, x_{it}) and identities (y_{it}, y_{iit}, p_{ijt}, c_{it}, nx_{it}). For each history, the series are filtered by the Hodrick and Prescott (1980) detrending method, and cross-correlations and standard deviations are computed. These statistics are then averaged over the 200 histories.

6 Business Cycle Properties of Two Experimental Economies

A summary of the parameters used for the two benchmark economies is given in Table 5. Tables 6 and 7 contain the statistics from the simulations described above. Figures 3 depicts the model J-curves. These statistics are to be compared to those in Tables 1 and 2.

The model is successful in several respects. First, regarding the facts common to all countries, the pattern of volatilities is largely replicated: investment fluctuates more than output, which is more volatile than consumption and employment. However, imports and exports are not volatile enough. Another success is that all aggregates are procyclical and the trade balance is countercyclical. The only departure from the data is that the terms of trade are procyclical instead of being acyclical. Notice that exports are less procyclical than other aggregates, just as in the data. Finally, the correlations between the trade balance and the terms of trade generate the typical J-curve.

Second, regarding differences between countries, the model simulations are also successful: The volatility of all aggregates is higher in the small countries, with the exception of the terms of trade in Canada. This is observed in the data, only the Swiss terms of trade should also have been less volatile. Persistence of all aggregates but the terms of trade is lower in the small countries. This was observed in the data, with the exception that Swiss terms of trade were less persistent and some Canadian aggregates were more persistent. Also, the model replicates the fact that consumption is more procyclical in large countries, to the contrary of trade aggregates. Finally, cross-correlations are higher among neighbors.

The model has, however, some failures. We already mentioned that imports and exports are not volatile enough and that the terms of trade are procyclical. Also, the volatility of imports varies too much from one country to another, but the persistence of consumption does not. Finally, the cross-correlations of consumption are systematically higher than those of output. This is a well known problem with international real business cycle models. Adding size differences as well as other asymmetries does therefore not solve this *quantity anomaly*, to cite Backus, Kehoe, & Kydland (1995).

Many facts are replicated, even though the model is rather simple. The differences arise mostly from the volatility of the terms of trade, too low, causing imports and exports to be too stable (or vice-versa). Also, it is puzzling that no consumption smoothing is observed in the data.

We should bear in mind that this model considers only technology shocks, and does not allows for other shocks. For example, terms of trade are clearly influenced by movements of the exchange rate, and others shocks which have not been explicitly modeled here, such as oil price shocks. Stronger movements of the terms of trade would probably lead to higher volatilities of imports and exports, as in the data. Despite the simplicity of the model, it mimics reasonably well the properties of the data.

7 Sensitivity of the Model to Alternative Specifications

In this section, we study how the statistics change if some parameters depart from the benchmark values or if some features of the model are altered. This is to establish whether the model is sensitive to imprecision in the parameters or to some of its features. Also, we can perform some counterfactual analysis. Among the large number of statistics, we discuss only a selection, which can be found in Tables 8 and 9.

The importance of trade in the transmission of shocks can be observed by removing all trade links. Then, the business cycle is transmitted only via the technological innovations. In autarky, there are very small departures from the benchmark economies (apart from the obvious), even for the small countries: there is only a slight decrease in the correlations of consumption across countries since risk-sharing of consumption through trade is not possible. So the bulk of the cross-correlations come from correlated shocks. We can therefore say that the influence of trade on business cycles is small, as has already been shown by Canova & Dellas (1990) and Dellas (1986) in different setups.

Now we reintroduce trade but remove international spillovers of shocks: all off-diagonal elements of A and V are set to zero. Although output is more variable, consumption becomes less variable due to the higher volatility of investment: a positive productivity shocks generates a larger increase in investment than consumption, which in turn is almost perfectly correlated to output. There are some significant changes in trade, without any remarkable pattern apart from the higher volatility of the terms of trade and net exports. Notice also that output levels are not correlated at all with each other, even between neighbors, and that the remaining cross-correlations of the consumption levels are attributable to the risk-sharing through trade.

We then add full domestic spillovers of shocks: A is the identity matrix and the technology parameter then follows a random walk. To the opposite of the two country experiments of Backus et al. (1994), we find significant differences with the benchmark economies. The J-curve is clearly not plausible for the large countries, trade tends to amplify the variation of output. Also, consumption and exports are nearly perfectly correlated with output, while imports are not at all. Reintroducing nonzero shock correlations (not in the tables) does not lead to more plausible results.

In the next experiment, we introduce time-to-build in the spirit of Kydland & Prescott (1982) with a two-quarter construction time for capital, whose law of motion is, instead of (5):

$$k_{i,t+1} = (1-\delta)k_{it} + s_{1it},$$

where s_{1it}, the investment initiated in $t-1$ becoming effective in $t+1$, has the law of motion:

$$s_{ji,t+1} = s_{j+1,it}, \quad j = 1.$$

Total investment is then the total of the resources dedicated to building capital at time t:

$$x_{it} = \frac{1}{2}\sum_{j=1}^{2} s_{jit}.$$

With this modification of the model, most of the aggregates behave more smoothly. The terms of trade and consumption are, however, more volatile than in the benchmark economies. All autocorrelations (not in the tables) are smaller, especially for consumption, net exports and terms of trade, which feature some two-quarter seasonality. Interestingly, the J-curve is now lower (with seasonality). Longer time-to-build features amplified departures from the benchmark.

So far the model assumed that trade was carried out within the quarter. We want now to introduce delivery lags of two types: complete time-to-ship, where all cross-border trade takes a quarter to reach its market; mixed time-to-ship, where this lag happens only with the far country (the rest of the World). We assume that the prices have been determined at delivery and that there are rational expectations on future prices and quantities. With complete time-to-ship, we have then for the investment-consumption aggregator and the terms of trade:

$$c_{it} + x_{it} = G(y_{iit}, y_{ji,t-1}, y_{ki,t-1}),$$

$$p_{ijt} = \frac{\frac{\partial G(y_{iit}, y_{ji,t-1}, y_{ki,t-1})}{\partial y_{ji,t-1}}}{\frac{\partial G(y_{iit}, y_{ji,t-1}, y_{ki,t-1})}{\partial y_{iit}}}.$$

In these experiments, trade is smoother, and the terms of trade are more volatile than in the benchmark economies, but still a far cry from the volatility observed in the data. Consumption in the small countries is more variable, as consumption smoothing becomes more costly. Autocorrelations (not depicted) are considerably lower for the international variables for the distant countries in the mixed time-to-ship case, for all countries with complete time-to-ship. These variables are also much less correlated to output and are lagging output. The J-curves are lower and to the right: the positive effect on the trade balance is more difficult to obtain and delayed. Notice that leads in the J-curves have virtually no correlation.

In the next experiment, we introduce transportation costs. Indeed, international trade is more costly than internal trade in terms of insurance and freight. We take account of this cost by cutting a portion of the income. We put the cost at 6% of imports, following the mean value of the *cif/fob* ratio in the industrialized countries as published in the International Financial Statistics. The new budget constraints of the households are, in the steady state:

$$w_{it}n_{it} + (r+\delta)k_{it} = \left(\omega_{ii}y_{iit}^{-\rho} + \omega_{ji}y_{jit}^{-\rho} + \omega_{ki}y_{kit}^{-\rho}\right)^{-\frac{1}{\rho}} + \tau(y_{jit} + y_{kit}),$$

where τ is the transportation cost per unit. The parameters ω_{ij} become then:

$$\omega_{ji} = y_{ji}^{\rho+1} y_i^{-1} \left[y_{ii} + (1-\tau)(y_{ji} + y_{ki})\right]^{-\rho},$$

$$\omega_{ii} = y_{ii}^{\rho+1} y_i^{-1} \left[y_{ii} + (1-\tau)(y_{ji} + y_{ki})\right]^{-\rho}.$$

Transportation cost increases the volatility of the trade aggregates, especially in the small countries, but has no noticeable effect on consumption or output. The J-curves move upwards for small leads and lags. There is no other significant change: The model is fairly robust to this specification.

The convexity of the utility function is not well established in the literature. The value $\gamma = -1$ has often been used in real business cycle models. However, Eichenbaum, Hansen, & Singleton (1988) show that γ can be close to zero, if not positive. We choose to run an experiment with $\gamma = 0$, the loglinear specification. The properties of the model economies show higher output volatility with less variability of consumption when agents are less risk averse. This leads to higher volatility of trade and smaller correlations between consumption and output. The other statistics are not significantly altered, except for those in the second partition where the J-curve is lower in the large countries.

The benchmark elasticity of substitution is 1.5. There is however some discussion in the trade literature about the accuracy of this figure, see Whalley (1985) or the contributions in Srinivasan & Whalley (1986). With small deviations from 1.5, the cyclical behavior of the economies is fairly robust compared to the benchmark economies except for the J-curve: it moves significantly up with the elasticity. The evidence from Zimmermann (1994b) is, however, that the elasticity could be much higher, and for some countries lower. Therefore, we run two experiments with elasticities of 0.5 and 4, titled in the tables lower and higher elasticity of substitution.

Changing the elasticities below 1 or higher than 2 can alter the results considerably, mostly for the international variables. We depict the evolution of some statistics for elasticities of substitution from 0.1 to 4 in the Figures 4 to 9. We see that the correlations of the trade balance with output or with the terms of trade get much stronger with more elastic substitution, to the contrary of imports with output. Exports become in most cases more procyclic. The volatility of exports and imports is greater with higher elasticity, while that of the terms of trade is lower.

Notice that several of these statistics are not monotone with the elasticity. One example is the volatility of imports: With low elasticity, any change in domestic demand has to be accommodated by variations in imports, driving their variability up. With high elasticity, imports are an easy way to increase supply, and they react strongly to fluctuations of other variables. Also, the higher the elasticity, the higher the autocorrelation for all international variables, but not in the small countries.

Finally, the J-curve turns positive sooner, especially for the larger countries, and reaches higher positive values. With lower elasticities than benchmark, its shape turns more into a V as contemporaneous correlations are strongly negative.

We see that the model is quite sensitive to significant changes in the elasticity of substitution. It is therefore important to have a rather accurate calibration, as some differences in the business cycle statistics across countries could be attributed to this elasticity. It is, however, doubtful that such an accurate measure is currently available. While the results in absolute terms can change quite a lot, they do not so in relative terms. From the Figures 4 to 9 it is apparent that the rankings of the countries change little. The diversity of the business cycle statistics across countries is therefore maintained with any elasticity of substitution (within a reasonable range).

8 Role of Size and Distance in the Business Cycle

In the previous sections, we have already hinted at some peculiarities originating in the heterogeneities built into the model. This section recapitulates them and offers a more detailed analysis. Specifically, we want to see which of the business cycle characteristics of the small or distant countries arise from which of their specificities.

The sensitivity analysis of Section 7 showed that small countries are, in most dimensions, much more sensitive to time-to-ship and transport costs but less sensitive to changes in the elasticity of substitution compared to larger countries. This comes from the fact that they have a larger trade share, but trade does not appear to have a large importance in the transmission of the shocks. We also observed that small countries typically have a higher volatility in all variables but the terms of trade. The correlation with output of consumption is smaller, but higher for the trade variables. The J-curve can be steeper than that of the large countries.

To see which parameters lead small countries to behave so typically, we proceed by counterfactual analysis: we insert values of the large neighbor for parameters of the small country. Then, the latter behaves like a large country with respect to one of its characteristics. The results of these experiments are given in Tables 10 and 11, where we give only the statistics for the small countries (the tables show also similar experiments for the distant country to be discussed later). One should, however, bear in mind that the following analysis is based on only two specific small countries. One has therefore to be careful in generalizing the following results to other small countries.

If the small country has the same, lower standard deviation for the technological innovations as its large neighbor, we observe that the volatility of output decreases much more than that of consumption. This difference is compensated mostly by imports. The volatility of the terms of trade also decreases a lot in Switzerland, where all correlations with output (but not imports) are affected. This may be a surprise as only the magnitude of the shocks, not their interrelation, has been altered. There is no strong change in the J-curve.

In the next experiment, we assume the small country has the same spillover effects than its large neighbors. We impose therefore the following constraints on the spillover matrix A: $a_{11} = a_{33}$, $a_{12} = a_{32}$, $a_{21} = a_{23}$, $a_{31} = a_{13}$. Also, we restrict the eigenvalues of the new spillover matrix to those of the benchmark case. This leaves two degrees of freedom: we impose the benchmark values for a_{11} and a_{12}. We have therefore for A in the two partitions:

$$\begin{pmatrix} 0.904 & 0.165 & -0.008 \\ 0.052 & 0.833 & 0.052 \\ -0.008 & 0.165 & 0.904 \end{pmatrix}, \begin{pmatrix} 0.941 & 0.152 & 0.010 \\ 0.029 & 0.820 & 0.029 \\ 0.010 & 0.152 & 0.941 \end{pmatrix}.$$

In this experiment, the volatilities of consumption, exports and the terms of trade go up, to the opposite of imports. These variables are then also more correlated to output, but imports and net exports. The J-curves become steeper and rise somewhat later (lower instantaneous correlation).

Finally, we impose import shares such that both neighboring countries (1 and 3) exhibit the same implicit size: $m_{11} = m_{33}$, $m_{21} = m_{23}$, $m_{31} = m_{13}$, $m_{12} = m_{32}$, $m_{11} + m_{21} + m_{31} = 1$, $m_{22} + 2m_{12} = 1$, $m_{21} = bm_{12}$, where m_{ij} is the import share from i to j and b is the relative size of country 2 to country 1. Again, we have two degrees of freedom, we choose to take m_{11} and m_{22} as in the benchmark economies. The import shares are then for each partition, in %:

$$\begin{pmatrix} 94.86 & 2.19 & 2.95 \\ 1.55 & 96.90 & 1.55 \\ 2.95 & 2.19 & 94.86 \end{pmatrix}, \begin{pmatrix} 91.75 & 3.075 & 5.175 \\ 1.835 & 96.33 & 1.835 \\ 5.175 & 3.075 & 91.75 \end{pmatrix}.$$

This experiment lowers the volatility of the trade balance in the small country to the level of the large countries and makes the J-curve less steep. The correlation of the trade balance increases with output. Also, the volatility of imports and exports decreases. There are no other significant changes, as it could be expected from the previous section where trade did not appear to be an important factor.

It is therefore possible to determine the origin of some of the business cycle characteristics of the small countries. The higher volatility of output is almost totally attributable to the high standard deviation of the shocks. The spillover effects and the above standard deviation have opposite influences on the volatility of consumption, of exports, and of the terms of trade. Imports variability is affected by all country-specific parameters, but mostly by the standard deviation. The volatility of the net exports depends, by definition, on the import shares, but also on the other parameters of small countries. The correlation with output of consumption increases with the standard deviation, but goes down because of the spillover effects. Correlation of imports are only influenced by the spillovers. The particular correlations of exports of small countries are mostly due to the spillovers, for net exports they are also attributable to the volatility of the shocks. These two specificities have an ambiguous effect on the correlations of output with the terms of trade. Finally, the slope of the J-curves are modified in opposite directions by the spillover effects and the import shares.

We now turn to the distant country with another series of experiments. It is however very difficult to distinguish the distance factor from the size factor in many parameters. As in both partitions the distant countries are the largest, part of the changes in the statistics below come from this size effect. In the benchmark economies, we could observe that the distant countries have a lower volatility of imports, and a rather low correlation of the trade balance with output. This can be attributed to the size factor, although distance may play a role. The most significant fact is the lower cross-correlations of output and consumption with their partners. We report the simulations for the later statistics in Table 12.

We do not expect the volatility of the innovations to be linked with distance. However the correlations across countries of these shocks show clearly higher values between neighbors. In the following experiment, we put all shock correlations at these high values. This has no clear effect on the volatility of the aggregates, maybe only a decline for the terms of trade. Exports are however significantly better correlated to output, to the opposite of the trade balance. The J-curve seems to be slightly flatter. The statistics change in each partition, but not in the same direction, so the effect of distance is ambiguous. Table 12 shows that the typical cross-correlations of output or consumption involving distant countries are largely due to the cross-correlation of innovations: the distant country has comparable numbers to the other ones.

In the sensitivity analysis, the spillovers appeared to explain the major part of the cross-correlations across countries of output and consumptions. The next experiment uses a spillover matrix A such that the spillovers of the two large countries with the small one are identical. We have therefore the constraints: $a_{13} = a_{23}$ and $a_{31} = a_{32}$, with the three same eigenvalues as in the benchmark economies. We have to make different choices for the free parameters in each partition because of implausible solutions (not real, or above one). The following matrices are used in this simulation:

$$\begin{pmatrix} 0.965 & 0.072 & 0.026 \\ 0.041 & 0.965 & 0.026 \\ -0.063 & -0.063 & 0.833 \end{pmatrix}, \begin{pmatrix} 0.934 & -0.015 & 0.086 \\ 0.029 & 0.934 & 0.086 \\ 0.063 & 0.063 & 0.834 \end{pmatrix}.$$

Again, there is no clear effect on the volatilities. This is also the case for the correlations, which change in opposite directions in the two partitions. It is also hard to distinguish any consistent change in the pattern of the J-curve. The cross-correlations in Table 12 become however more uniform across countries, hereby confirming the presumption from the sensitivity analysis. Apart from the later, it is very difficult to interpret this experiment, as it not only involves a change in the distance between countries, but also in their size. Indeed, we had to put the restriction $a_{11} = a_{22}$ to get plausible parameters.

9 Conclusions

This paper presents an international real business cycle model with three countries that differ in size and in the strength of their relations. The model is illustrated with two examples, the first relating Switzerland to Europe and to the rest of the developed World. The second example deals with Canada, the United States and an aggregate of Europe and Japan.

Using a model calibrated with values from the literature or from own calculations, we observe that experimental economies reproduce reasonably well some key properties of actual economies in the past 25 years. Focussing on technological shocks, the model seems, however, too simple to account for the high volatility in the terms of trade. The model appears to be fairly robust to changes in calibration and specification, except for the elasticity of substitution between goods of different origin or the hypothesis that the technology shocks follow a random walk. The introduction of delivery lags (time-to-ship) implies more volatility for the terms of trade and shifts the J-curves. Transportation costs do not seem to alter the statistics significantly, even for small and open economies. Indeed, trade does not have a strong effect on the business cycle. The dynamics of the technology shocks (spillovers, instantaneous correlations) are the main determinants of international comovements.

The effect of the countries' size is clear from the data and from the simulations, and can be explained by counterfactual analysis. A smaller country has generally a higher volatility and less persistence for output, consumption, investment, the trade balance and employment. Terms of trade are less volatile and less persistent and the J-curve is more pronounced. The volatilities are mostly influenced by the standard deviations of the shocks. Import shares have an influence mainly on trade variables. Only the volatilities of consumption, exports and terms of trade are affected by spillover effects. Consumption and output are more correlated in large countries as it is more difficult for them to smooth consumption with trade. Correlations of aggregates with output are mostly linked to spillover effects. The J-curves are modified in opposite directions by the spillovers and the import shares. The fact that two countries are distant from each other translates into lower cross-correlations, especially for outputs. This comes mainly from the lower correlation of innovations, but also from the lower spillovers between these countries.

This model should be further developed along three lines: the calibration should be country-specific for some parameters, as for example the capital income share and the elasticity of substitution. The second line deals with building in additional sources of shocks, such as monetary or fiscal disturbances. Monetary shocks have not yet be proven to be relevant for closed economies, but considering the very high volatility of the terms of trade, exchange rate considerations are to be included, although Baxter & Stockman (1989) suggest that the exchange rate regime has no strong effect. The third line of research is to study current account dynamics more precisely. We considered here only trade of goods and services, but capital movements are today also a very important means of sharing risks across economies.

A Sources of the Data

The procedure used for the *import shares* runs as follows:

- Determine the import share of each of the countries by the ratio of imports of goods and services to GDP. We used the series published in the OECD national accounts at current prices and at current exchange rate. The European aggregate englobes all countries member of the OECD.

- Determine the relative share of the foreign countries in the imports. We used the statistics of the Direction of Trade published by the IMF. As services are not considered in this source, we computed relative shares only for imports of goods. The European aggregate englobes all countries member of IMF. Note that the countries outside of Japan, North America and Europe have been neglected, that is the later three entities account for the full import share.

- Remove the internal trade from the import shares. Therefore trade between Germany and France is treated as domestic trade for the European aggregate.

The OECD data are also used to determine the *relative sizes of the countries* of Table 3.

For the *business cycle statistics*, we used the largest possible number of European countries having quarterly national accounts in the International Financial Statistics database of the IMF. These countries building up the European aggregate are Austria, France, Germany, Italy, Switzerland and the United Kingdom. We used also Finland for a shorter sample (70.I to 89.IV), but the results were not significantly altered. Of course we have also data for Canada, Japan and the United States. For Switzerland, we used quarterly data from the Office fédéral des affaires conjuncturelles, whose data set is longer than that of the IMF. We aggregated these data using Summers & Heston (1988) tables on real output and international prices for 1985. Each of the output series (GDP, GNP for the United States and Germany) is multiplied to give the Summers and Heston figures. The European GDP is furthermore adjusted by a constant multiplicative factor to account for all European OECD countries. The other series are multiplied by the same national coefficients as GDP and then aggregated across countries. The terms of trade are a weighted sum of the individual terms of trade, where the weight is the country share to total output at each quarter. The terms of trade are calculated as the ratio of unit values of import to unit values of export (if not available, their respective deflators). The statistics for all series are finally computed after applying the Hodrick & Prescott (1980) filter from 1965.I to 1989.IV, that is 100 periods. Statistics involving consumption do not include Italy. Terms of trade for Canada in 1989 set at the 88.IV figure as not yet available. For the smoothing parameter, we used 1600.

For the *Solow residuals*, we used the same GDP series as for the business cycle statistics. The employment data (civilian employment) is from OECD and national statistical offices from 65.I to 89.IV. The European aggregate is the same as for the business cycle statistics and is also adjusted for size. We experienced in adding Finland and Sweden on a sample from 70.I to 89.IV, without obtaining significantly different results.

This data is available on the Internet. Use any Web browser and point to
`http://www.er.uqam.ca/nobel/r14160/`
to retrieve this and other data.

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Table 1: Business cycle statistics, 1965.I to 1989.IV.

	Europe (-)	ROW 1	Switzer-land	United States	ROW 2	Canada
Standard deviations (in %)						
output	1.11	1.53	2.09	1.83	1.06	1.46
consumption	0.93	1.13	1.81	1.35	0.80	1.38
investment	2.64	3.72	6.24	5.56	2.63	4.07
imports	5.12	5.47	6.80	5.65	5.71	6.14
exports	3.78	5.56	4.42	6.92	4.01	4.90
net exports*	0.12	0.09	1.48	0.46	0.10	0.79
terms of trade	2.90	3.77	2.91	3.29	3.69	2.39
employment	0.55	0.76	1.54	1.08	0.46	1.36
Autocorrelations:						
output	0.74	0.84	0.65	0.86	0.73	0.80
consumption	0.57	0.77	0.31	0.76	0.55	0.77
imports	0.82	0.80	0.81	0.66	0.84	0.82
exports	0.75	0.84	0.64	0.80	0.78	0.76
net exports*	0.77	0.69	0.56	0.77	0.82	0.62
terms of trade	0.86	0.81	0.60	0.79	0.86	0.83
Correlations:						
(consumption, output)	0.72	0.86	0.57	0.87	0.73	0.71
(imports, output)	0.45	0.37	0.72	0.54	0.44	0.79
(exports, output)	0.38	0.18	0.48	0.15	0.34	0.74
(net exports*, output)	-0.34	-0.35	-0.61	-0.36	-0.41	-0.30
(terms of trade, output)	-0.03	-0.25	0.39	-0.12	-0.06	-0.18
(net exports*, t. of trade)	-0.57	0.06	-0.55	0.21	-0.56	-0.05
Relative size:	0.39	0.60	0.01	0.42	0.54	0.04

* as a share of output.

Sources and method: see Appendix. Europe(-) does not include Switzerland.

Table 2: Cross-correlations of output and of consumption, 1965.I to 1989.IV.

	Europe (-)	ROW 1	Switzer-land
Output with output:			
Europe(-)	1.00	0.57	0.61
ROW 1	0.57	1.00	0.24
Switzerland	0.61	0.24	1.00
Consumption with consumption:			
Europe(-)	1.00	0.30	0.25
ROW 1	0.30	1.00	0.15
Switzerland	0.25	0.15	1.00
	United States	ROW 2	Canada
Output with output:			
United States	1.00	0.53	0.77
ROW 2	0.53	1.00	0.48
Canada	0.77	0.48	1.00
Consumption with consumption:			
United States	1.00	0.34	0.71
ROW 2	0.34	1.00	0.18
Canada	0.71	0.18	1.00

Sources and method: see Appendix.
Europe(-) does not include Switzerland.

Table 3: Import shares and country sizes, mean of 1965-89, in %.

from: / to:	Europe (-)	ROW 1	Switzer-land	relative size	implicit size from data
Europe(-)	94.86	4.24	0.90	40.9	39.1
ROW 1	2.93	96.90	0.17	57.7	59.7
Switzerland	29.70	4.11	66.19	1.4	1.2
from: / to:	United States	ROW 2	Canada	relative size	implicit size from data
United States	91.75	5.41	2.84	35.3	42.5
ROW 2	3.15	96.33	0.52	59.1	53.6
Canada	18.70	4.60	76.70	5.6	3.9

Sources and method: see Appendix. Europe(-) does not include Switzerland.

Table 4: Technology innovations: Standard deviations, correlation matrix and lagged spillovers.

St. dev. (%)		Correlations			Spillovers		
		Europe (-)	ROW 1	Switzerland	Europe (-)	ROW 1	Switzerland
Europe(-)	0.731	1.000	0.143	0.418	0.904	0.072	0.026
					(0.050)	(0.032)	(0.037)
ROW 1	0.760	0.143	1.000	0.127	0.052	0.965	-0.022
					(0.051)	(0.033)	(0.039)
Switzerland	1.463	0.418	0.127	1.000	0.188	-0.023	0.772
					(0.099)	(0.064)	(0.075)
		United States	ROW 2	Canada	United States	ROW 2	Canada
United States	0.808	1.000	0.164	0.257	0.942	0.001	0.031
					(0.050)	(0.029)	(0.056)
ROW 2	0.707	0.164	1.000	0.102	0.029	0.935	0.086
					(0.043)	(0.025)	(0.049)
Canada	0.911	0.257	0.102	1.000	0.156	0.056	0.828
					(0.056)	(0.032)	(0.063)

Sources and method: see Appendix. Europe(-) does not include Switzerland.
Numbers in parentheses are standard errors.

Table 5: Parameter values of the benchmark economies.

Preferences

$$\beta = 0.99, \mu = 0.34, \gamma = -1.0, \sigma = \frac{1}{1+\rho} = 1.5.$$

Technology

$$\theta = 0.35, \delta = 0.025.$$

Import shares (%)

Partition I (Switzerland) — Partition II (Canada)

$$(y_{jk}) = \begin{pmatrix} 94.86 & 4.24 & 0.90 \\ 2.93 & 96.90 & 0.17 \\ 29.70 & 4.11 & 66.19 \end{pmatrix} \qquad \begin{pmatrix} 91.75 & 5.41 & 2.84 \\ 3.15 & 96.33 & 0.52 \\ 18.70 & 4.60 & 76.70 \end{pmatrix}$$

Technology shocks

$$A = \begin{pmatrix} 0.904 & 0.072 & 0.026 \\ 0.052 & 0.965 & -0.022 \\ 0.188 & -0.023 & 0.772 \end{pmatrix} \qquad \begin{pmatrix} 0.941 & 0.001 & 0.031 \\ 0.029 & 0.934 & 0.086 \\ 0.156 & 0.056 & 0.827 \end{pmatrix}$$

$$10000V = \begin{pmatrix} 0.534 & 0.079 & 0.447 \\ 0.079 & 0.578 & 0.141 \\ 0.447 & 0.141 & 2.140 \end{pmatrix} \qquad \begin{pmatrix} 0.653 & 0.094 & 0.189 \\ 0.094 & 0.500 & 0.066 \\ 0.189 & 0.066 & 0.830 \end{pmatrix}$$

Number of simulated histories: 200.
Length of simulated series: 100 quarters.
Order of countries:
Partition I: Europe(-), ROW 1 (Canada, Japan, United States), Switzerland;
Partition II: United States, ROW 2 (Europe, Japan), Canada.

Table 6: Business cycle statistics for the benchmark economies.

	Europe (-)	ROW 1	Switzer-land	United States	ROW 2	Canada
Standard deviations (in %):						
output	1.26	1.17	2.53	1.28	1.25	1.54
	(0.18)	(0.15)	(0.32)	(0.18)	(0.25)	(0.21)
consumption	0.58	0.66	0.73	0.69	0.71	0.67
	(0.09)	(0.09)	(0.10)	(0.10)	(0.11)	(0.09)
investment	3.88	2.90	11.52	3.66	4.38	6.30
	(0.61)	(0.46)	(1.77)	(0.56)	(1.07)	(1.10)
imports	1.08	0.91	2.93	1.43	0.86	1.66
	(0.17)	(0.14)	(0.42)	(0.33)	(0.14)	(0.25)
exports	1.07	1.06	1.38	0.70	1.43	1.03
	(0.15)	(0.18)	(0.23)	(0.13)	(0.38)	(0.19)
net exports*	0.06	0.04	0.90	0.13	0.06	0.43
	(0.01)	(0.01)	(0.13)	(0.02)	(0.01)	(0.06)
terms of trade	0.42	0.52	0.56	0.48	0.55	0.39
	(0.07)	(0.09)	(0.10)	(0.10)	(0.15)	(0.08)
employment	0.58	0.39	1.29	0.45	0.68	0.74
	(0.08)	(0.05)	(0.15)	(0.06)	(0.10)	(0.08)
Autocorrelations:						
output	0.67	0.67	0.60	0.66	0.69	0.62
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)
consumption	0.71	0.70	0.69	0.70	0.69	0.69
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
imports	0.71	0.70	0.56	0.65	0.72	0.62
	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)
exports	0.63	0.72	0.74	0.81	0.66	0.68
	(0.08)	(0.07)	(0.07)	(0.06)	(0.08)	(0.08)
net exports*	0.59	0.66	0.54	0.64	0.66	0.57
	(0.09)	(0.09)	(0.08)	(0.08)	(0.08)	(0.08)
terms of trade	0.79	0.78	0.82	0.77	0.76	0.83
	(0.07)	(0.07)	(0.05)	(0.07)	(0.07)	(0.05)
Correlations:						
(consumption, output)	0.82	0.96	0.83	0.95	0.59	0.75
	(0.07)	(0.02)	(0.07)	(0.02)	(0.16)	(0.11)
(imports, output)	0.88	0.77	0.95	0.88	0.81	0.94
	(0.04)	(0.09)	(0.01)	(0.04)	(0.07)	(0.02)
(exports, output)	0.44	0.38	0.71	0.00	0.26	0.38
	(0.14)	(0.15)	(0.07)	(0.14)	(0.17)	(0.15)
(net exports*, output)	-0.58	-0.54	-0.81	-0.87	-0.44	-0.74
	(0.10)	(0.13)	(0.05)	(0.04)	(0.17)	(0.08)
(terms of trade, output)	0.56	0.64	0.67	0.21	0.74	0.59
	(0.13)	(0.11)	(0.07)	(0.29)	(0.09)	(0.11)
(net exports*, t.of trade)	-0.36	-0.44	-0.37	-0.11	-0.05	-0.36
	(0.11)	(0.13)	(0.07)	(0.26)	(0.27)	(0.09)

* as a share of output.

Numbers in parentheses are standard deviations across replications.

Table 7: Cross-correlations for the benchmark economies.

	Europe (-)	ROW 1	Switzer-land
Output with output:			
Europe(-)	1.00	-0.04	0.40
	(0.00)	(0.19)	(0.14)
ROW 1	-0.04	1.00	0.03
	(0.19)	(0.00)	(0.18)
Switzerland	0.40	0.03	1.00
	(0.14)	(0.18)	(0.00)
Consumption with consumption:			
Europe(-)	1.00	0.66	0.75
	(0.00)	(0.13)	(0.10)
ROW 1	0.66	1.00	0.46
	(0.13)	(0.00)	(0.17)
Switzerland	0.75	0.46	1.00
	(0.10)	(0.17)	(0.00)

	United States	ROW 2	Canada
Output with output:			
United States	1.00	-0.15	0.10
	(0.00)	(0.18)	(0.18)
ROW 2	-0.15	1.00	-0.05
	(0.18)	(0.00)	(0.18)
Canada	0.10	-0.05	1.00
	(0.18)	(0.18)	(0.00)
Consumption with consumption:			
United States	1.00	0.72	0.82
	(0.00)	(0.15)	(0.10)
ROW 2	0.72	1.00	0.75
	(0.15)	(0.00)	(0.15)
Canada	0.82	0.75	1.00
	(0.10)	(0.15)	(0.00)

Numbers in parentheses are standard deviations across replications.

Table 8: Business cycle statistics for data, benchmark and alternative specifications.

	Standard deviations						Correlations						Cross-correlations					
	outp	cons	imp	exp	n.exp	tot	c,y	imp,y	exp,y	nx,y	tot,y	nx,tot	outp/outp			cons/cons		
Properties of the data																		
Europe (-)	1.11	0.93	5.12	3.78	0.12	2.90	0.72	0.45	0.38	-0.34	-0.03	-0.57	1.00	0.57	0.61	1.00	0.30	0.25
ROW 1	1.53	1.13	5.47	5.56	0.09	3.77	0.86	0.37	0.18	-0.35	-0.25	0.06	0.57	1.00	0.24	0.30	1.00	0.15
Switzerland	2.09	1.81	6.80	4.42	1.48	2.91	0.57	0.72	0.48	-0.61	0.39	-0.55	0.61	0.24	1.00	0.25	0.15	1.00
United States	1.83	1.35	5.65	6.92	0.46	3.29	0.87	0.54	0.15	-0.36	-0.12	0.21	1.00	0.53	0.77	1.00	0.34	0.71
ROW 2	1.06	0.80	5.71	4.01	0.10	3.69	0.73	0.44	0.34	-0.41	-0.06	-0.56	0.53	1.00	0.48	0.34	1.00	0.18
Canada	1.46	1.38	6.14	4.90	0.79	2.39	0.71	0.79	0.74	-0.30	-0.18	-0.05	0.77	0.48	1.00	0.71	0.18	1.00
Benchmark economies																		
Europe (-)	1.26	0.58	1.08	1.07	0.06	0.42	0.82	0.88	0.44	-0.58	0.56	-0.36	1.00	-0.04	0.40	1.00	0.66	0.75
ROW 1	1.17	0.66	0.91	1.06	0.04	0.52	0.96	0.77	0.38	-0.54	0.64	-0.44	-0.04	1.00	0.03	0.66	1.00	0.46
Switzerland	2.53	0.73	2.93	1.38	0.90	0.56	0.83	0.95	0.71	-0.81	0.67	-0.37	0.40	0.03	1.00	0.75	0.46	1.00
United States	1.28	0.69	1.43	0.70	0.13	0.48	0.95	0.88	0.00	-0.87	0.21	-0.11	1.00	-0.15	0.10	1.00	0.72	0.82
ROW 2	1.25	0.71	0.86	1.43	0.06	0.55	0.59	0.81	0.26	-0.44	0.74	-0.05	-0.15	1.00	-0.05	0.72	1.00	0.75
Canada	1.54	0.67	1.66	1.03	0.43	0.39	0.75	0.94	0.38	-0.74	0.59	-0.36	0.10	-0.05	1.00	0.82	0.75	1.00
Autarky																		
Europe (-)	1.26	0.58	0.00	0.00	0.00	0.00	0.84	0.00	0.00	0.00	0.00	0.00	1.00	-0.04	0.40	1.00	0.61	0.67
ROW 1	1.14	0.66	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	-0.04	1.00	0.05	0.61	1.00	0.31
Switzerland	2.52	0.75	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.40	0.05	1.00	0.67	0.31	1.00
United States	1.31	0.64	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	1.00	-0.14	0.11	1.00	0.67	0.76
ROW 2	1.25	0.73	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	-0.14	1.00	-0.05	0.67	1.00	0.73
Canada	1.54	0.71	0.00	0.00	0.00	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.11	-0.05	1.00	0.76	0.73	1.00
No international spillovers																		
Europe (-)	1.34	0.40	1.18	0.93	0.06	0.61	0.94	0.76	0.42	-0.69	0.53	-0.35	1.00	0.01	-0.01	1.00	0.13	0.16
ROW 1	1.30	0.54	0.81	1.23	0.03	0.66	0.97	0.67	0.60	-0.30	0.78	-0.36	0.01	1.00	-0.00	0.13	1.00	0.08
Switzerland	2.57	0.54	3.09	1.19	1.06	0.71	0.93	0.94	0.53	-0.86	0.63	-0.39	-0.01	-0.00	1.00	0.16	0.08	1.00
United States	1.45	0.48	1.04	1.02	0.10	0.58	0.96	0.84	0.54	-0.63	0.75	-0.46	1.00	0.01	-0.01	1.00	0.12	0.23
ROW 2	1.27	0.43	1.02	1.00	0.04	0.60	0.96	0.73	0.52	-0.58	0.61	-0.48	0.01	1.00	0.00	0.12	1.00	0.09
Canada	1.65	0.39	1.72	0.96	0.43	0.57	0.91	0.91	0.42	-0.79	0.54	-0.42	-0.01	0.00	1.00	0.23	0.09	1.00
Random walk																		
Europe (-)	1.12	0.66	1.08	1.09	0.03	1.05	0.98	-0.01	0.94	0.42	0.72	0.75	1.00	-0.05	-0.07	1.00	0.19	0.40
ROW 1	1.13	0.70	1.14	1.23	0.02	1.12	0.99	-0.06	0.98	0.65	0.74	0.94	-0.05	1.00	0.03	0.19	1.00	0.20
Switzerland	2.50	0.77	1.34	2.08	0.35	1.48	0.83	0.79	0.94	-0.46	0.91	-0.33	-0.07	0.03	1.00	0.40	0.20	1.00
United States	1.24	0.68	0.81	1.10	0.04	0.93	0.98	0.15	0.95	0.30	0.81	0.55	1.00	-0.04	-0.07	1.00	0.23	0.43
ROW 2	1.05	0.65	1.10	1.07	0.02	1.02	0.99	-0.02	0.98	0.57	0.70	0.90	-0.04	1.00	-0.02	0.23	1.00	0.20
Canada	1.50	0.60	0.84	1.25	0.13	0.97	0.87	0.52	0.92	-0.21	0.84	-0.14	-0.07	-0.02	1.00	0.43	0.20	1.00
Time-to-build																		
Europe (-)	1.23	0.58	1.05	1.04	0.06	0.46	0.83	0.84	0.49	-0.55	0.56	-0.28	1.00	-0.03	0.41	1.00	0.64	0.74
ROW 1	1.15	0.67	0.91	1.05	0.03	0.72	0.96	0.70	0.43	-0.49	0.62	-0.33	-0.03	1.00	0.03	0.64	1.00	0.45
Switzerland	2.44	0.73	2.68	1.40	0.81	0.61	0.84	0.94	0.76	-0.79	0.69	-0.36	0.41	0.03	1.00	0.74	0.45	1.00
United States	1.25	0.69	1.38	0.68	0.12	0.50	0.95	0.85	0.10	-0.85	0.25	-0.08	1.00	-0.14	0.12	1.00	0.71	0.81
ROW 2	1.22	0.71	0.83	1.40	0.05	0.58	0.61	0.75	0.31	-0.39	0.74	-0.01	-0.14	1.00	-0.03	0.71	1.00	0.73
Canada	1.49	0.68	1.54	1.02	0.39	0.44	0.76	0.92	0.46	-0.71	0.61	-0.33	0.12	-0.03	1.00	0.81	0.73	1.00
Time-to-ship (mixed)																		
Europe (-)	1.25	0.59	0.97	1.01	0.05	0.59	0.82	0.74	0.51	-0.54	0.65	-0.29	1.00	-0.05	0.41	1.00	0.66	0.75
ROW 1	1.14	0.67	0.86	0.99	0.04	0.69	0.96	0.53	0.50	-0.16	0.38	-0.71	-0.05	1.00	0.02	0.66	1.00	0.46
Switzerland	2.50	0.74	2.62	1.38	0.76	0.55	0.84	0.96	0.75	-0.80	0.67	-0.42	0.41	0.02	1.00	0.75	0.46	1.00
United States	1.27	0.69	1.26	0.68	0.11	0.63	0.95	0.75	0.09	-0.85	0.45	-0.30	1.00	-0.16	0.11	1.00	0.72	0.81
ROW 2	1.25	0.72	0.73	1.36	0.07	0.77	0.58	0.64	0.30	-0.22	0.46	-0.54	-0.16	1.00	-0.05	0.72	1.00	0.75
Canada	1.52	0.68	1.44	1.01	0.37	0.40	0.75	0.94	0.46	-0.70	0.61	-0.44	0.11	-0.05	1.00	0.81	0.75	1.00
Time-to-ship (complete)																		
Europe (-)	1.25	0.59	1.00	0.94	0.05	0.67	0.81	0.65	0.56	-0.55	0.64	-0.23	1.00	-0.05	0.41	1.00	0.66	0.65
ROW 1	1.17	0.67	0.86	0.99	0.04	0.69	0.96	0.53	0.50	-0.16	0.38	-0.71	-0.05	1.00	0.02	0.66	1.00	0.36
Switzerland	2.38	1.00	2.22	1.47	0.95	0.89	0.72	0.67	0.84	-0.18	0.24	-0.81	0.41	0.02	1.00	0.65	0.36	1.00
United States	1.26	0.69	1.33	0.63	0.11	0.80	0.95	0.61	0.21	-0.83	0.47	-0.22	1.00	-0.16	0.11	1.00	0.73	0.80
ROW 2	1.25	0.72	0.72	1.37	0.07	0.77	0.58	0.64	0.30	-0.23	0.47	-0.54	-0.16	1.00	-0.04	0.73	1.00	0.75
Canada	1.48	0.77	1.31	1.00	0.43	0.65	0.68	0.69	0.56	-0.30	0.31	-0.76	0.11	-0.04	1.00	0.80	0.75	1.00
Transportation costs																		
Europe (-)	1.27	0.58	1.19	1.21	0.06	0.42	0.82	0.88	0.42	-0.52	0.41	-0.21	1.00	-0.04	0.40	1.00	0.67	0.80
ROW 1	1.18	0.66	1.00	1.17	0.03	0.53	0.96	0.76	0.39	-0.55	0.68	-0.36	-0.04	1.00	0.03	0.67	1.00	0.51
Switzerland	2.63	0.67	3.45	1.56	1.00	0.64	0.76	0.94	0.63	-0.82	0.59	-0.16	0.40	0.03	1.00	0.80	0.51	1.00
United States	1.29	0.59	1.40	0.69	0.11	0.46	0.95	0.88	0.02	-0.84	0.02	0.08	1.00	-0.14	0.11	1.00	0.72	0.84
ROW 2	1.26	0.70	0.96	1.56	0.06	0.58	0.60	0.81	0.26	-0.45	0.71	0.06	-0.14	1.00	-0.04	0.72	1.00	0.76
Canada	1.58	0.64	1.87	1.21	0.44	0.43	0.71	0.94	0.34	-0.75	0.57	-0.15	0.11	-0.04	1.00	0.84	0.76	1.00
Loglinear utility function																		
Europe (-)	1.35	0.51	1.19	1.15	0.07	0.39	0.74	0.91	0.39	-0.61	0.53	-0.41	1.00	-0.03	0.40	1.00	0.67	0.78
ROW 1	1.26	0.58	1.01	1.16	0.04	0.48	0.92	0.83	0.31	-0.58	0.61	-0.48	-0.03	1.00	0.04	0.67	1.00	0.45
Switzerland	2.71	0.62	3.14	1.46	0.97	0.58	0.66	0.95	0.70	-0.82	0.67	-0.38	0.40	0.04	1.00	0.78	0.45	1.00
United States	1.39	0.58	1.42	0.84	0.13	0.44	0.91	0.90	0.12	-0.83	0.33	-0.25	1.00	-0.12	0.12	1.00	0.70	0.82
ROW 2	1.34	0.63	1.01	1.36	0.06	0.49	0.52	0.87	0.22	-0.55	0.70	-0.24	-0.12	1.00	-0.04	0.70	1.00	0.75
Canada	1.66	0.58	1.80	1.12	0.47	0.41	0.63	0.95	0.38	-0.74	0.57	-0.37	0.12	-0.04	1.00	0.82	0.75	1.00
Lower elasticity of substitution																		
Europe (-)	1.24	0.59	1.16	1.10	0.09	0.49	0.85	0.99	0.26	-0.67	0.56	-0.78	1.00	-0.02	0.42	1.00	0.60	0.68
ROW 1	1.15	0.68	1.01	1.13	0.06	0.63	0.97	0.98	0.13	-0.68	0.65	-0.85	-0.02	1.00	0.09	0.60	1.00	0.32
Switzerland	2.77	0.79	2.95	1.14	1.04	0.93	0.90	0.98	0.66	-0.90	0.68	-0.72	0.42	0.09	1.00	0.68	0.32	1.00
United States	1.29	0.66	1.42	0.77	0.15	0.66	0.97	0.98	-0.11	-0.81	0.07	-0.51	1.00	-0.11	0.15	1.00	0.65	0.74
ROW 2	1.23	0.72	1.04	1.30	0.07	0.68	0.61	0.98	0.04	-0.74	0.76	-0.50	-0.11	1.00	-0.06	0.65	1.00	0.70
Canada	1.46	0.70	1.65	1.06	0.50	0.61	0.80	0.98	0.30	-0.78	0.69	-0.67	0.15	-0.06	1.00	0.74	0.70	1.00
Higher elasticity of substitution																		
Europe (-)	1.30	0.57	1.30	1.34	0.09	0.30	0.76	0.57	0.51	-0.12	0.49	0.56	1.00	-0.09	0.39	1.00	0.75	0.80
ROW 1	1.20	0.64	1.24	1.39	0.05	0.36	0.94	0.31	0.51	0.06	0.59	0.63	-0.09	1.00	-0.02	0.75	1.00	0.61
Switzerland	2.71	0.68	3.51	1.38	1.16	0.32	0.73	0.88	0.55	-0.62	0.50	0.26	0.39	-0.02	1.00	0.80	0.61	1.00
United States	1.32	0.71	1.49	1.30	0.17	0.31	0.90	0.60	0.25	-0.32	0.43	0.52	1.00	-0.25	0.07	1.00	0.78	0.88
ROW 2	1.29	0.64	1.30	1.68	0.08	0.39	0.55	0.39	0.30	-0.10	0.58	0.56	-0.25	1.00	-0.06	0.78	1.00	0.78
Canada	1.64	0.66	2.17	1.14	0.55	0.24	0.70	0.86	0.25	-0.68	0.32	0.30	0.07	-0.06	1.00	0.88	0.78	1.00

Table 9: Correlations between terms of trade and net exports/output (J-curve).

Lag:	-3	-2	-1	0	+1	+2	+3	+4	+5
Properties of the data									
Europe(-)	-0.52	-0.65	-0.67	-0.57	-0.33	-0.05	0.22	0.41	0.51
ROW 1	0.03	0.02	0.00	0.06	0.26	0.49	0.60	0.56	0.41
Switzerland	-0.32	-0.56	-0.43	-0.55	-0.32	-0.28	0.01	0.15	0.35
United States	0.16	0.15	0.13	0.21	0.38	0.54	0.63	0.59	0.46
ROW 2	-0.63	-0.69	-0.68	-0.56	-0.32	-0.02	0.25	0.45	0.56
Canada	-0.01	-0.05	-0.06	-0.05	0.01	0.08	0.20	0.29	0.29
Benchmark economies									
Europe(-)	-0.38	-0.40	-0.40	-0.36	0.06	0.32	0.46	0.52	0.51
ROW 1	-0.41	-0.43	-0.44	-0.44	0.02	0.31	0.48	0.56	0.58
Switzerland	-0.43	-0.46	-0.44	-0.37	0.12	0.38	0.50	0.53	0.49
United States	-0.29	-0.27	-0.21	-0.11	0.12	0.26	0.33	0.36	0.36
ROW 2	-0.25	-0.22	-0.15	-0.05	0.12	0.23	0.28	0.31	0.31
Canada	-0.43	-0.46	-0.44	-0.36	0.12	0.39	0.53	0.56	0.52
No international spillovers									
Europe(-)	-0.36	-0.37	-0.37	-0.35	0.04	0.30	0.44	0.51	0.52
ROW 1	-0.36	-0.38	-0.38	-0.36	0.04	0.31	0.46	0.54	0.56
Switzerland	-0.44	-0.47	-0.46	-0.39	0.10	0.38	0.52	0.56	0.53
United States	-0.42	-0.45	-0.46	-0.46	-0.02	0.28	0.46	0.55	0.57
ROW 2	-0.42	-0.45	-0.47	-0.48	-0.01	0.30	0.48	0.58	0.61
Canada	-0.43	-0.46	-0.46	-0.42	0.03	0.32	0.48	0.55	0.55
Random walk									
Europe(-)	0.06	0.24	0.47	0.75	0.70	0.62	0.54	0.45	0.35
ROW 1	0.14	0.35	0.61	0.94	0.77	0.62	0.48	0.35	0.23
Switzerland	-0.37	-0.38	-0.36	-0.33	0.09	0.37	0.55	0.62	0.63
United States	-0.08	0.08	0.28	0.55	0.62	0.63	0.59	0.53	0.45
ROW 2	0.08	0.29	0.56	0.90	0.76	0.62	0.49	0.37	0.26
Canada	-0.32	-0.28	-0.23	-0.14	0.24	0.48	0.61	0.65	0.63
Time-to-build									
Europe(-)	-0.37	-0.30	-0.41	-0.28	-0.15	0.38	0.28	0.57	0.36
ROW 1	-0.41	-0.32	-0.46	-0.33	-0.18	0.38	0.29	0.62	0.42
Switzerland	-0.37	-0.40	-0.41	-0.36	-0.10	0.40	0.34	0.56	0.37
United States	-0.28	-0.22	-0.22	-0.08	-0.04	0.28	0.20	0.39	0.26
ROW 2	-0.26	-0.16	-0.17	-0.01	-0.03	0.26	0.16	0.35	0.21
Canada	-0.38	-0.38	-0.41	-0.33	-0.11	0.41	0.34	0.58	0.39
Time-to-ship (mixed)									
Europe(-)	-0.23	-0.22	-0.21	-0.29	-0.12	0.13	0.29	0.36	0.37
ROW 1	-0.15	-0.15	-0.12	-0.71	-0.01	0.16	0.27	0.33	0.34
Switzerland	-0.43	-0.45	-0.44	-0.42	0.02	0.36	0.52	0.57	0.54
United States	-0.16	-0.06	0.01	-0.30	-0.21	-0.00	0.14	0.23	0.26
ROW 2	0.03	0.09	0.18	-0.54	-0.17	-0.06	0.04	0.10	0.13
Canada	-0.40	-0.41	-0.39	-0.44	-0.02	0.33	0.51	0.57	0.55
Time-to-ship (complete)									
Europe(-)	-0.20	-0.18	-0.22	-0.23	-0.19	0.07	0.23	0.31	0.34
ROW 1	-0.14	-0.14	-0.13	-0.71	-0.01	0.15	0.26	0.32	0.33
Switzerland	-0.09	-0.11	0.17	-0.80	0.01	0.09	0.19	0.21	0.21
United States	-0.06	-0.01	0.04	-0.22	-0.30	-0.09	0.05	0.15	0.19
ROW 2	0.03	0.09	0.18	-0.54	-0.16	-0.06	0.03	0.10	0.13
Canada	-0.09	-0.10	0.02	-0.76	-0.12	0.04	0.19	0.25	0.27
Transportation costs									
Europe(-)	-0.36	-0.35	-0.31	-0.21	0.16	0.38	0.49	0.52	0.50
ROW 1	-0.40	-0.41	-0.40	-0.36	0.08	0.36	0.52	0.59	0.59
Switzerland	-0.45	-0.44	-0.35	-0.16	0.25	0.46	0.54	0.53	0.48
United States	-0.24	-0.19	-0.08	0.08	0.23	0.31	0.34	0.34	0.32
ROW 2	-0.23	-0.17	-0.08	0.06	0.18	0.26	0.29	0.31	0.30
Canada	-0.42	-0.40	-0.32	-0.15	0.24	0.44	0.53	0.53	0.49
Loglinear utility function									
Europe(-)	-0.42	-0.44	-0.45	-0.41	0.03	0.31	0.45	0.51	0.51
ROW 1	-0.44	-0.47	-0.49	-0.48	-0.02	0.27	0.45	0.53	0.56
Switzerland	-0.44	-0.47	-0.46	-0.38	0.11	0.38	0.50	0.53	0.49
United States	-0.37	-0.37	-0.34	-0.25	0.05	0.25	0.36	0.42	0.43
ROW 2	-0.36	-0.35	-0.32	-0.24	0.03	0.21	0.32	0.38	0.40
Canada	-0.44	-0.47	-0.45	-0.37	0.11	0.39	0.52	0.55	0.52
Lower elasticity of substitution									
Europe(-)	-0.45	-0.57	-0.68	-0.78	-0.35	-0.06	0.14	0.26	0.24
ROW 1	-0.44	-0.57	-0.71	-0.85	-0.45	-0.16	0.05	0.20	0.28
Switzerland	-0.41	-0.53	-0.63	-0.72	-0.26	0.04	0.22	0.31	0.34
United States	-0.32	-0.40	-0.46	-0.51	-0.27	-0.08	0.05	0.14	0.20
ROW 2	-0.32	-0.39	-0.45	-0.50	-0.28	-0.10	0.02	0.11	0.18
Canada	-0.42	-0.53	-0.61	-0.67	-0.23	0.06	0.23	0.33	0.37
Higher elasticity of substitution									
Europe(-)	0.03	0.18	0.36	0.57	0.77	0.82	0.77	0.66	0.52
ROW 1	0.07	0.24	0.43	0.63	0.85	0.91	0.87	0.76	0.61
Switzerland	-0.30	-0.19	-0.02	0.26	0.60	0.72	0.71	0.63	0.51
United States	-0.02	0.13	0.31	0.52	0.72	0.80	0.79	0.71	0.60
ROW 2	0.06	0.21	0.38	0.56	0.72	0.77	0.74	0.66	0.55
Canada	-0.28	-0.16	-0.03	0.30	0.62	0.74	0.73	0.64	0.51

Table 10: Business cycle properties of alternative specifications for the small or distant countries.

	Standard deviations						Correlations with output				
	outp	cons	imp	exp	n.exp	t.of t	cons	imp	exp	n.exp	t.of t
Small countries											
Benchmark economies											
Switzerland	2.53	0.73	2.93	1.38	0.90	0.56	0.83	0.95	0.71	-0.81	0.67
Canada	1.54	0.67	1.66	1.03	0.43	0.39	0.75	0.94	0.38	-0.74	0.59
Standard deviation of large neighbor											
Switzerland	1.35	0.51	1.65	0.99	0.51	0.34	0.71	0.94	0.64	-0.68	0.39
Canada	1.38	0.63	1.53	1.00	0.40	0.36	0.72	0.94	0.35	-0.73	0.56
Spillovers of large neighbor											
Switzerland	2.47	1.09	2.55	1.45	0.79	0.84	0.82	0.92	0.76	-0.79	0.78
Canada	1.56	0.70	1.37	1.18	0.32	0.59	0.82	0.89	0.65	-0.61	0.72
Import shares of large neighbor											
Switzerland	2.55	0.75	2.25	1.16	0.10	0.58	0.86	0.98	0.70	-0.86	0.62
Canada	1.54	0.70	1.43	0.96	0.13	0.35	0.75	0.95	0.34	-0.78	0.63
Distant countries											
Benchmark economies											
ROW 1	1.17	0.66	0.91	1.06	0.04	0.52	0.96	0.77	0.38	-0.54	0.64
ROW 2	1.25	0.71	0.86	1.43	0.06	0.55	0.59	0.81	0.26	-0.44	0.74
Uniform correlations of innovations											
ROW 1	1.15	0.68	0.98	1.09	0.03	0.41	0.96	0.85	0.57	-0.44	0.54
ROW 2	1.21	0.74	0.80	1.49	0.06	0.55	0.64	0.79	0.35	-0.34	0.76
Spillovers of other large country											
ROW 1	1.24	0.70	1.14	0.80	0.04	0.52	0.89	0.80	0.29	-0.75	0.50
ROW 2	1.23	0.65	0.88	1.23	0.05	0.53	0.72	0.79	0.42	-0.43	0.72

Table 11: Correlations between terms of trade and net exports/output (J-curve).

Lag:	-3	-2	-1	0	+1	+2	+3	+4	+5
Small countries									
Benchmark economies									
Switzerland	-0.43	-0.46	-0.44	-0.37	0.12	0.38	0.50	0.53	0.49
Canada	-0.43	-0.46	-0.44	-0.36	0.12	0.39	0.53	0.56	0.52
Standard deviations of large neighbor									
Switzerland	-0.41	-0.43	-0.41	-0.32	0.11	0.35	0.46	0.49	0.47
Canada	-0.43	-0.45	-0.42	-0.33	0.13	0.40	0.52	0.55	0.52
Spillovers of large neighbor									
Switzerland	-0.44	-0.47	-0.48	-0.44	0.01	0.31	0.49	0.57	0.58
Canada	-0.41	-0.45	-0.45	-0.44	-0.00	0.28	0.46	0.54	0.57
Import shares of large neighbor									
Switzerland	-0.36	-0.37	-0.36	-0.31	0.12	0.35	0.47	0.50	0.47
Canada	-0.41	-0.44	-0.42	-0.34	0.13	0.40	0.53	0.55	0.52
Distant countries									
Benchmark economies									
ROW 1	-0.41	-0.43	-0.44	-0.44	0.02	0.31	0.48	0.56	0.58
ROW 2	-0.25	-0.22	-0.15	-0.05	0.12	0.23	0.28	0.31	0.31
Uniform correlations of innovations									
ROW 1	-0.40	-0.42	-0.43	-0.42	0.03	0.32	0.48	0.55	0.57
ROW 2	-0.22	-0.17	-0.10	0.02	0.14	0.22	0.25	0.27	0.27
Spillovers of other large country									
ROW 1	-0.40	-0.41	-0.42	-0.40	0.03	0.31	0.47	0.54	0.56
ROW 2	-0.34	-0.34	-0.32	-0.28	0.05	0.26	0.38	0.44	0.46

Table 12: Correlations of output and consumption across countries in the distant country experiments.

	Outputs			Consumptions		
Country	(1)	(2)	(3)	(1)	(2)	(3)
Benchmark economies						
(1) Europe(-)	1.00	-0.04	0.40	1.00	0.66	0.75
(2) ROW 1	-0.04	1.00	0.03	0.66	1.00	0.46
(3) Switzerland	0.40	0.03	1.00	0.75	0.46	1.00
(1) United States	1.00	-0.15	0.10	1.00	0.72	0.82
(2) ROW 2	-0.15	1.00	-0.05	0.72	1.00	0.75
(3) Canada	0.10	-0.05	1.00	0.82	0.75	1.00
Uniform correlation of innovations						
(1) Europe(-)	1.00	0.25	0.35	1.00	0.80	0.79
(2) ROW 1	0.25	1.00	0.31	0.80	1.00	0.68
(3) Switzerland	0.35	0.31	1.00	0.79	0.68	1.00
(1) United States	1.00	-0.07	0.10	1.00	0.76	0.82
(2) ROW 2	-0.07	1.00	0.09	0.76	1.00	0.80
(3) Canada	0.10	0.09	1.00	0.82	0.80	1.00
Spillovers of other large country						
(1) Europe(-)	1.00	-0.07	0.16	1.00	0.72	0.72
(2) ROW 1	-0.07	1.00	-0.06	0.72	1.00	0.56
(3) Switzerland	0.16	-0.06	1.00	0.72	0.56	1.00
(1) United States	1.00	0.01	0.09	1.00	0.67	0.79
(2) ROW 2	0.01	1.00	-0.09	0.67	1.00	0.72
(3) Canada	0.09	-0.09	1.00	0.79	0.72	1.00

Figure 1: Two partitions of the world

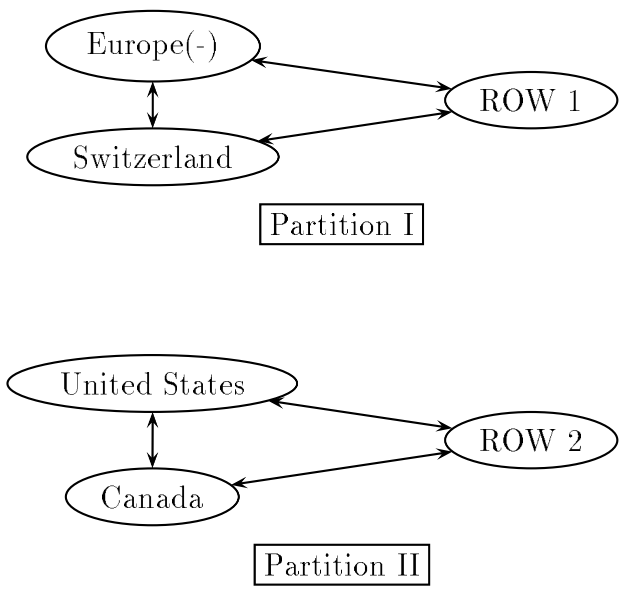

Figure 2: J-curves, properties of the data

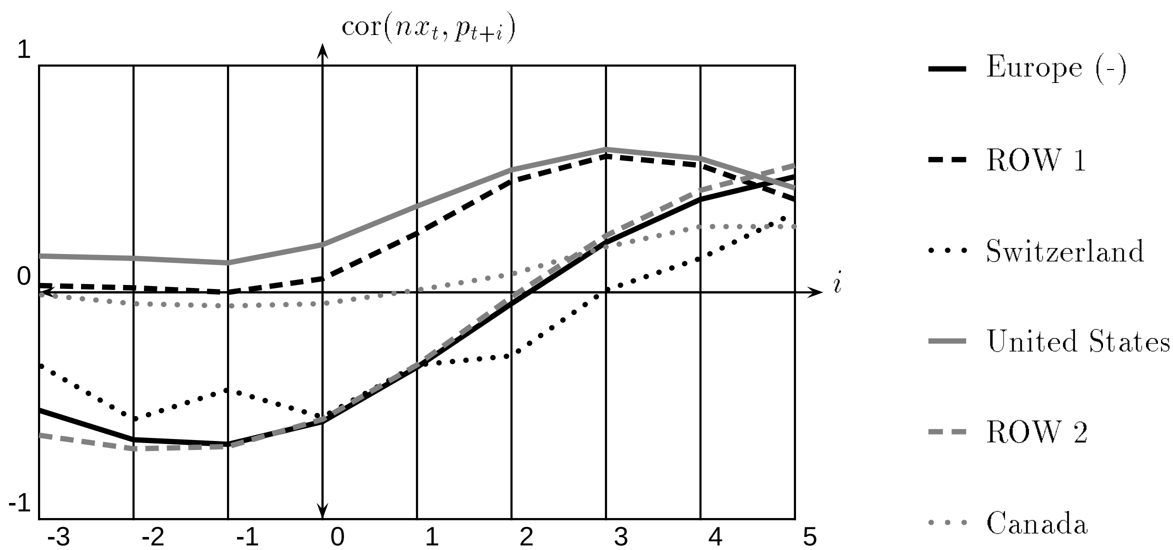

Figure 3: J-curves, properties of the simulations

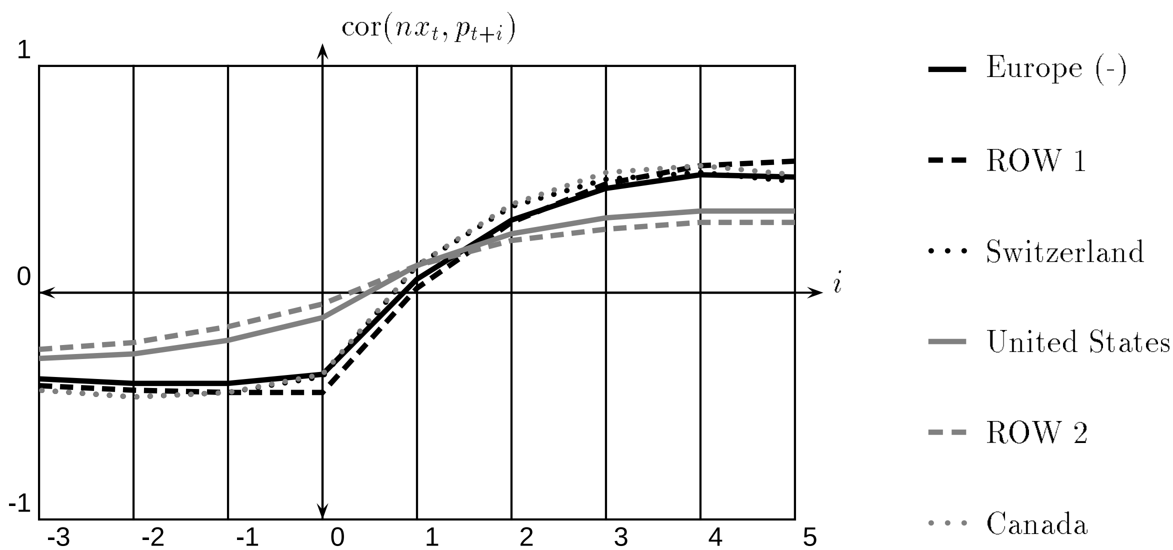

Figure 4: Corr(imports, output), depending on elasticity of substitution σ.

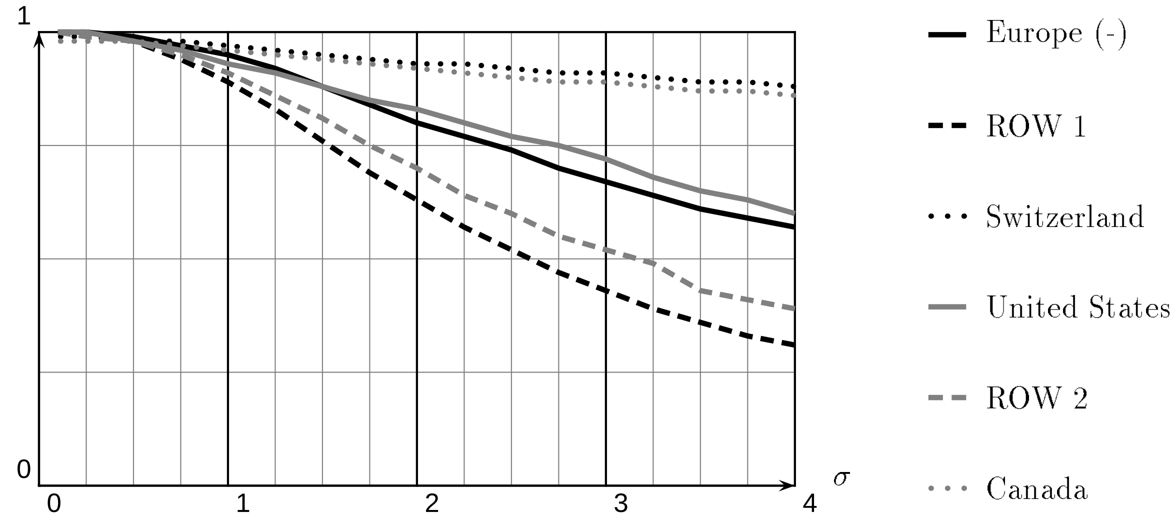

Figure 5: Corr(exports, output), depending on elasticity of substitution σ.

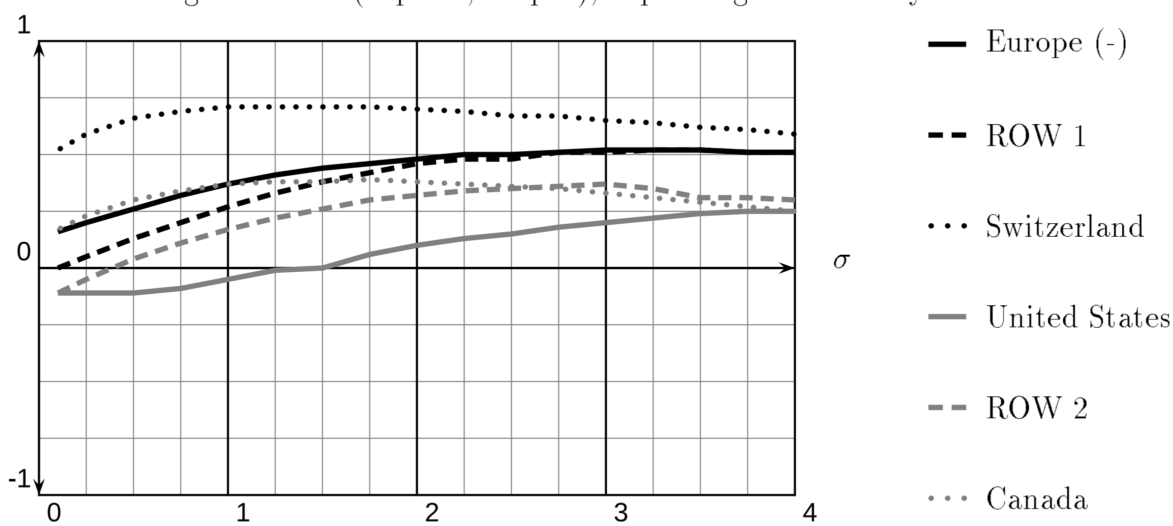

Figure 6: Corr(trade balance, output), depending on elasticity of substitution σ.

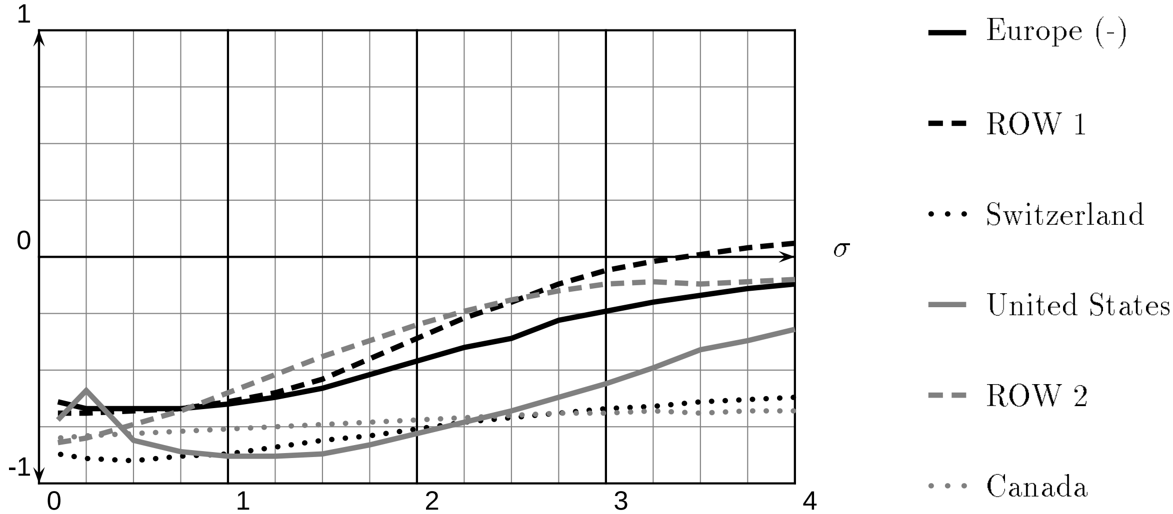

Figure 7: Corr(trade balance, terms of trade), depending on elasticity of substitution σ.

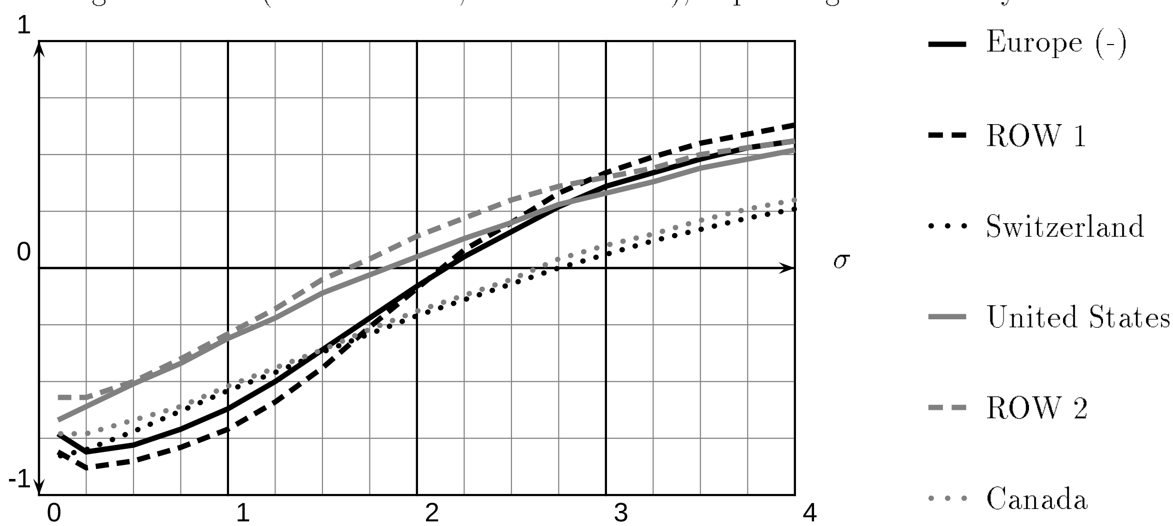

Figure 8: Standard deviation of imports, depending on elasticity of substitution σ.

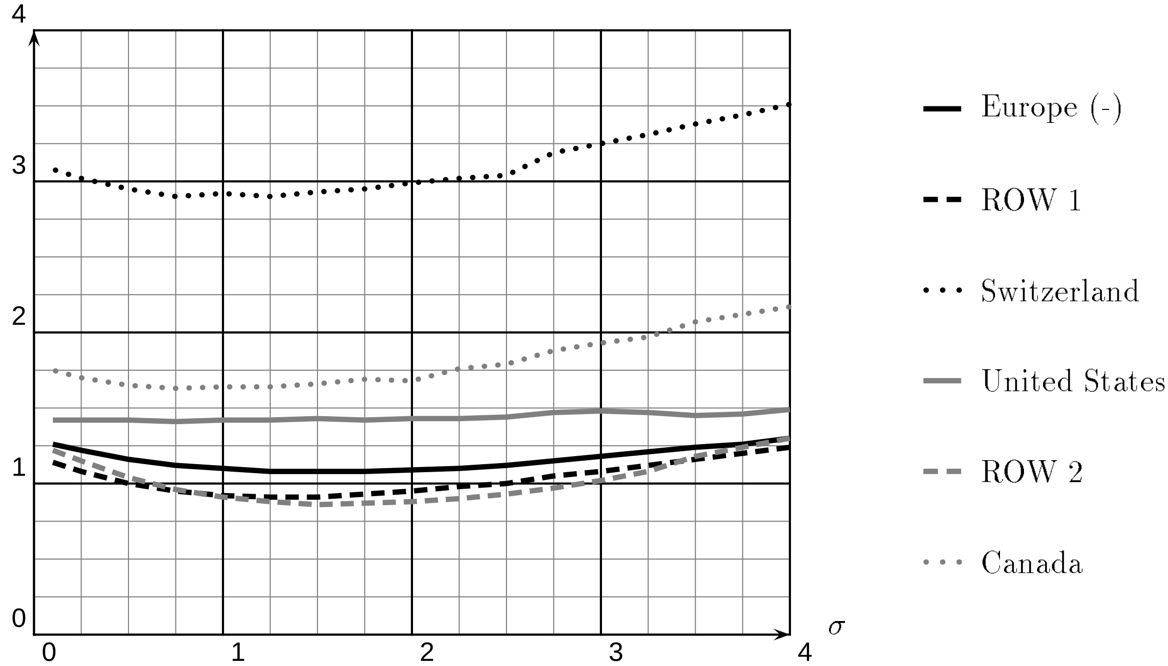

Figure 9: Standard deviation of exports, depending on elasticity of substitution σ.