# The US economy, the dollar and their impact on some industrialised economies in the 90s [1]: simulations with the MARMOTTE multicountry model.

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***SUMMARY***

In this paper we seek to assess to what extent the most relevant stylised facts about the US economy can be explained by a combination of simple shocks, using a macro-econometric model with strong theoretical foundations. To this end, we will use a series of permanent supply shocks raising US total factor productivity, and of preference shocks which change the perceived riskiness of the US financial assets compared to that of Canadian European and Japanese ones. In particular, we aim at taking into account that a part of the dramatic boom of the US economy has to do with the stock market bubble, originated by a sizeable misperception by economic agents of the growth prospects of the US economy. Using quite an elaborate simulation strategy we try to model the effects of a sudden change in expectations. Secondly, we will also assess to what extent the simple transmission of shocks to the other industrialised countries using the channels traditionally present in macroeconomic models can explain the evolution of the business cycle in these other countries. Moreover, we shall compare the effects of US shock on big and relatively closed economies such as the Euro zone and Japan and on a small, very open country such as Canada.

Within the theoretical framework of our model, we find that productivity shocks can explain the US GDP expansion and the deterioration of its trade balance over this period. However, they cannot explain the strong raise in consumption and employment nor the appreciation of the US dollar. Moreover, a scenario based on productivity shocks underestimates the importance of the downturn, which occurred in 2001-2002, and cannot explain the continuation of the deterioration of the US trade balance nor the depreciation of the dollar.

Changes in the perception of US risk by financial markets can explain the increase in investment, consumption and employment, the appreciation of the dollar and the deterioration of the trade balance in the first period. They can also explain the strong downturn and the depreciation of the dollar in the second period. A counterfactual feature, which is not observed for productivity shocks, is that the change in GDP is almost immediate, at the beginning of the expansion or the recession period. This series of shocks cannot explain the continuation of the deterioration of the US balance of trade in recent years, which is due to some features of consumption behaviour that cannot be easily rendered by this kind of models.

*Abstract*

In this paper we have attempted to explain stylised facts, which took place in the world economy over the last ten years by using a structural multinational model, called Marmotte, and by hitting this model with a small number of basic shocks. The combination of these shocks allows a good understanding of what happened in the United States and of the spillover of business conditions in the US to other industrialised countries. However, we have been unable to explain why the bad conditions in the US in 2002 and 2003 and the depreciation of the dollar have coincided with some deterioration of the US trade balance. The paper starts by a brief description of Marmotte and its main features. Then, we introduce the first scenario, based on a permanent productivity shock to the US economy, and describe the general results and what we obtained using a more elaborated shock featuring revisions in agents' expectations. Finally, we describe the second scenario, a reduction in the perceived risk of the US assets vis-à-vis Canadian, European and Japanese ones: again we will sketch the general results and introduce the effects of changes in the mood of investors.

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RESUME

**L'économie des Etats Unis, le dollar et leurs répercussions sur quelques pays industrialisés pendant les années 90.**

Cet article a pour but d'évaluer dans quelle mesure les faits stylisés les plus important de l'économie américaine peuvent être expliqués par une combinaison de chocs simples, utilisant un modèle macro-économétrique a fort contenu théorique. Nous utilisons une série de chocs de productivité permanents et des chocs de préférence qui altèrent le risque perçu des actifs américains par rapport a celui des actif européens, japonais et canadiens. Tout d'abord, nous tentons de chiffrer la part de l'évolution de l'économie américaine due à la bulle sur le marché des actions, causée par une erreur de perception des perspectives de croissance américaine. Deuxièmement nous évaluons la part des fluctuations dans les économies des pays industrialisés due à la simple transmission des chocs américains, à travers les canaux qui sont normalement présents dans les modèles macro-économétriques. Finalement nous comparons les effets des chocs américains sur des économies de grande taille et relativement fermées comme le Japon et la zone Euro et un pays de petite taille très ouvert comme le Canada.

Dans le cadre théorique du modèle, nous trouvons que les chocs de productivité arrivent à bien expliquer l'expansion du PIB des Etats-Unis et la forte détérioration de la balance commerciale de ce pays pendant la période d'expansion. Néanmoins ils ne sont pas capables d'expliquer ni la forte hausse de la consommation privée et de l'emploi, ni l'appréciation du dollar. Ils tendent aussi à sous-estimer le ralentissement de la croissance observé en 2001 et 2002. En outre ils n'expliquent pas la détérioration prolongée de la balance courante, ni la forte dépréciation du dollar de 2002 et 2003.
Les changements dans la perception du risque des actifs américains, expliquent assez bien l'augmentation des investissements, de la consommation et de l'emploi, ainsi que l'appréciation du dollar et le creusement du déficit extérieur. Ils donnent aussi une explication assez convaincante du retournement de la croissance, qui fut rapide, et de la dépréciation du dollar qui suivit. Néanmoins, ce type de chocs est incapable de reproduire la détérioration de la balance courante, qui résulte de caractéristique de la consommation privée qui sont difficile à introduire dans ce type de modèle. Finalement les deux chocs sont combinés et donnent un cadre assez réaliste des développement de ces dernières années.

Résumé court

Dans cet article nous essayons d'expliquer les principaux faits stylises de l'économie mondiale des dix dernières années à l'aide d'un modèle structurel multinational (MARMOTTE), en simulant les effets d'un nombre réduit de chocs. La combinaison de ces chocs permet une bonne compréhension des fluctuations aux Etats-Unis et des répercussions sur les autres pays industrialisés. Néanmoins les simulations ne sont pas capables d'expliquer pourquoi le ralentissement prononcé de la croissance et l'affaiblissement du dollar sont accompagnés d'une détérioration du solde courant. La première partie de l'article est consacrée à une description synthétique de MARMOTTE. Ensuite le premier scénario, basé sur une augmentation permanente de la productivité aux Etats-Unis est présenté et les résultats sont commentés. Dans la partie suivante les chocs de productivité sont combinés pour tenir compte de changements dans les anticipations des agents. Enfin un second scénario est développé dans lequel les agents modifient leur perception du risque des actifs américains.

J.E.L.: C53, D58, F42

Mots-clés: modèles économétriques, modelés d'équilibre général, transmission internationale des chocs.

## *1.Introduction*

The last ten years saw a long expansion period in the US, followed by disappointing performances in 2001 and 2002. Over the expansion period, investment growth rate was high and rising, GDP, households' consumption and employment were increasing at steady and high rates. The US dollar steadily appreciated against the euro and the Canadian dollar. The deficit of the trade balance stayed at moderate levels for some time, then increased strongly after 1998. During the slow down, which followed, the fixed investment growth rate decreased quickly and turned negative. The consumption and GDP growth rates decreased. Employment also decreased. However, the depreciation of the dollar against the euro occurred after some time, and that by the end of 2003 there is still no sign of an improvement of the balance of trade. During, all these years, inflation stayed low, even if it increased by a small amount in the last years of the expansion, then decreased afterward[3].

The first aim of this paper is to assess to what extent the most relevant stylised facts about the US economy can be explained by a combination of simple shocks, using a macro-econometric model with strong theoretical foundations. We will use a series of permanent supply shocks raising US total factor productivity, and of risk premia shocks which lower the perceived riskiness of the US financial assets compared to that of Canadian, European and Japanese assets. Moreover we aim at taking into account as many commentators suggested, that some of the dramatic boom of the US economy had to do with the stock market bubble, originated by a sizeable misperception by economic agents of the growth prospects of the US economy. Using quite an elaborate simulation strategy (described below) we try to model the effects of a sudden change in expectations. We will also assess to what extent the simple transmission of shocks to the other industrialised countries using the channels traditionally present in this kind of macroeconomic models can explain a part of business condition in these other countries[4]. As, our simulations will not introduce shocks specific to Canada, Europe and Japan, we will not try to reproduce the business condition in these countries and zone. However, we will investigate the spill over of shocks hitting the US to other countries. Moreover, we shall compare the effects of US shock on big, and relatively closed economies such as the Euro zone and Japan and on a small, very internationally integrated country like Canada.

Within the theoretical framework of our model, we find that productivity shocks can explain the US GDP expansion and the deterioration of its trade balance over the expansion period. However, they cannot explain the strong rise in consumption and employment nor the appreciation of the US dollar. Moreover, a scenario based on productivity shocks underestimates the importance of the downturn, which occurred in 2001-2002, and cannot explain the continuation of the deterioration of the US trade balance nor the depreciation of the dollar in the recent years.

[3] See appendix D for a few graphs on the stylised facts.

[4] The results of the simulations of Marmotte can sometimes be difficult to interpret. So we built a "maquette", called Koala, which represents a single country open on the rest of the world. The model takes into account all the complexities of the putty-clay specification of Marmotte. However, the other blocks of the model are much simpler, especially their dynamics. Koala can easily be simulated on any PC with Gauss or Matlab softwares. All the simulations given in this paper were also made on Koala. The results for the US given by Marmotte are quite consistent with the results given by Koala, and so probably are robust. Koala and its computer programs are available from Jean-Pierre Laffargue.

Changes in the perception of US risk by financial markets can explain the increase in investment, consumption and employment, the appreciation of the dollar and the deterioration of the balance of trade in the first period. They can also explain the strong downturn and the depreciation of the dollar in the second period. A counterfactual feature, which is not observed for productivity shocks, is that the change in GDP is almost immediate, at the beginning of the expansion or the recession period. This series of shock cannot explain the continuation of the deterioration of the US balance of trade in recent years, which is due to some features of consumption behaviour that cannot be easily rendered by this kind of models.

The first kind of shocks we investigated is located in the US and strongly asymmetrical. The spill over from the US economy to other industrialised countries is quite strong. However, it is weaker for Canada than for Europe and Japan, for reasons, which will be given in the paper. The second kind of shocks hits the US on one hand, and Canada Europe and Japan on the other hand, with opposite effects. Finally the two shocks are combined.

Section 2 lays out a brief description of the model and its main features. In section 3 we introduce the first scenario, based on a permanent productivity shock to the US economy, describing the general results and what we obtained using a more elaborated shock featuring revisions in agents' expectations. In the following section we describe the second scenario, a reduction in the perceived risk of US assets *vis-à-vis* Canadian, European and Japanese ones: again we will sketch the general results and introduce the effects of changes in the mood of investors. Section 5 combines the two previous shocks. Section 6 concludes.

## *2. Presentation of Marmotte*[5]

Marmotte is a multinational model including 17 industrialised countries and the rest of the world. It can be used to simulate the consequences of changes in economic policies and environment, in the neighbourhood of a baseline account. This account was built independently of the model and is based on the forecasts of international economic institutions. Each country is modelled by the same system of about 50 equations. The values of the parameters of these equations can differ across countries. Economic interdependencies between nations pass through international trade, exchange rates and capital flows. Thus, Marmotte is an instrument adapted to the analysis of the transmission of international shocks and to the evaluation of the international consequences of national policies, in the short and medium-run. The model is simulated under Troll.

Marmotte has strong theoretical foundations. It assumes that economic agents optimise inter-temporally and base their current actions on consistent forecasts of the future. It includes a modelling of the demand for goods and services on one hand and of potential output on the other hand. Disequilibrium between potential output and demand drives a change in prices. Governments' budgets and the balance of payments of nations must satisfy an inter temporal solvency constraint forbidding the use of Ponzi finance. Thus, the stabilisation of public and foreign debts is warranted by adequate increases in taxes and in the domestic interest rate.

The main features of Marmotte[6] are:

[5] A detailed presentation of the model can be found in Cadiou et al (2001) .

[6] To simplify the interpretation of the results and to reduce the time of simulation, this paper uses a version of Marmotte with only 4 countries or zone: the US, Canada, Japan and the Euro area. With this specification a simulation takes between 15 and 20 minutes under a Pentium 3, 1.8 Ghz with 256 Mo RAM.

1. Production technology is putty-clay[7]. Firms can pick the capital intensity of the investment undertaken in the period from a menu of available choices, represented by a CES function. This choice cannot be changed afterwards. The only decision firms can make about their existing capital units is to scrap them once they are no longer profitable. New investment entails an increase in employment whereas scrapping leads to firings. This specification allows for a detailed formalisation of employment dynamics. A change in factor costs won't then affect the volume and the capital intensity of new investments but just the scrapping of the old ones. Putty-clay technology is especially adapted to the investigation of medium-run movements. A change in technology will bear only on investments made after the time of the innovation. So, its effects will progressively diffuse over time. Similarly, a change in the bargaining power of trade unions will progressively translate in a change in the capital intensity of the production process when old production units are progressively substituted by new ones.

2. Investment can be financed in four different ways: via retained earnings, or by issuing stocks, or by short-term bonds in domestic currency or in US dollars[8]. The model assumes that profits are taxed in the country where enterprises are located, with no distinction among the nature of the profits (interest income, dividends, and capital gains). Therefore, following the Modigliani and Miller theorem, firms are indifferent among the financing methods. Households hold short-term bonds both in domestic currency and in US dollars. If these assets were perfectly substitute, uncovered interest parity would equate domestic to US rates, after having taken into account the expected currency depreciation rate. However, Marmotte assumes that households tend to diversify their portfolio. Therefore, the short-term interest rate on US bills will decrease when the share of dollar denominated assets in total wealth decreases. This variable risk premium is the mechanism, which prevents countries from using Ponzi finance to pay for their trade deficit. Savers are indifferent between acquiring equities and domestic short-term bonds. However, the ex-post payoff of investment can change in an unanticipated way. For example, an unexpected rise in wages, lowering firms' profits, will reduce equity prices and dividends. Savers are supposed to be neutral towards this kind of risk. However, when it happens, the shareholders' return can be lower than expected. It is important to stress that forecast errors are totally borne by households located in the same country as the enterprise. To sum up, Marmotte introduces two kinds of capital market imperfections. First, only dollar denominated assets are traded internationally and are imperfect substitutes for domestic assets. Secondly, the equities issued by a firm in one country are entirely held by the resident in that country.

3. Marmotte includes a wage curve which sums up wage bargaining on the labour market. The real cost of labour to firms is related to the productivity of labour, employment and the wedge. The wedge, which is the ratio between the real cost of labour and the real wage rate, is a function of taxes and social compensations and of the ratio between the consumption price index and the production deflator.

4. Each country produces a single good, which is imperfectly substitutable with other countries' output. Therefore real exchange rates can vary. Marmotte assumes a stickiness of production prices: in each country the inflation rate depends on the difference between the (effective) demand and the supply (potential output) of domestic goods, that is on the output gap. Current output is assumed to be equal to effective demand. In the long run effective demand and potential output are equal. The assumption of a single domestic good is far from innocent.

[7] The description of the putty-clay part of the model is given in Cadiou et al. (2002)

[8] Marmotte also includes long term bonds issued in domestic currency by borrowers in every country. There is therefore for each country a long-term interest rate and a term structure equation. A country holds US long-term bonds and short-term bills according to fixed and exogenous shares. The budget deficit is financed in each country by domestic short and long-term bonds, the shares of which are fixed.

When the productivity of a country increases, the supply of its domestic good on the world market increases and its real exchange rate *depreciates*. If we had assumed that each country produced a tradable good (without any country-specificity) and a non-tradable good, we would have had a different mechanism. An increase in the productivity *of the tradable good sector* in a country would have caused a transfer of factors from its non-tradable sector to its tradable one, with a consequent increase the price of non-tradable goods and *a* real exchange rate appreciation[9].

5. In each country or zone, the central bank has a reaction function determining its monetary policy. If observed inflation exceeds its target, the short-term nominal rate is increased relatively to its equilibrium value[10]. As Marmotte assumes that the interest rate overreacts to an increase in inflation, the real interest rate increases too. So, Marmotte determines without ambiguity the inflation and the exchange depreciation dynamics. Thus, the paths of the price level and of the exchange rate will depend on their initial values. In short these values provide nominal anchors to the economy. This hysteresis of nominal variables when the central bank reaction functions uses no nominal anchor, is well known in economic theory, at least since Wicksell.

6. There are two types of households. Those with no access to the credit market consume out of their current disposable income only. The others compute their total wealth (including the human capital) over an infinite time horizon and determine their current and future consumption plan, taking into account interest rates. The inter-temporal utility of this second kind of households is non-separable. This means that the utility felt by these agents in a period depends not only on their current consumption, but also on its past levels. Households accustomed to high levels of consumption will be much more demanding with their present level of consumption than households used to more frugal living condition. This specification reduces the volatility of consumption. The discount rate of households is assumed to be the same in the four countries or zone.

7. In the long run the exports of a country are a log-linear function of a foreign demand index and of the competitiveness of its domestic good on foreign markets. Imports are a log-linear function of a national demand index and of the competitiveness of foreign goods relatively to the domestic good. Current exports and imports are related to their long-run demand through error correction models.

The version of Marmotte we use in this paper only includes four countries or zones: the US, Canada, Japan and the Euro zone, supplemented of course by the rest of the world. We rewrote the model in reduced (detrended) variables and computed its linear approximation in the neighbourhood of a reference steady state. This linear approximation has 545 non redundant lead variables and as many eigenvalues with absolute value larger than 1. So, the local Blanchard and Kahn's conditions for the existence and the uniqueness of a solution of the model are satisfied. Moreover, Marmotte has 4 eigenvalues equal to 1, as many as independent central banks. These eigenvalues are related to the nominal hysteresis of the model, induced by monetary rules, which only include inflation rates and no price levels. Finally, there are many complex eigenvalues, near 1, with the same frequencies as the harmonics of the lifetime of capital (about 40 years). They can be interpreted as the Fourier decomposition of the echo effect.

### *3. Productivity shock*

[9] Hunt and Rebucci (2003) performed an exercise similar to our usin a model with an explicit distinction between tradables and non tradables.

[10] The Euro zone inflation and interest rates are a weighted average of national data.

The belief that the massive introduction of IT technology has raised US total factor productivity is widely shared, even though there is no agreement on the size of productivity gains. Another aspect, which we believe is quite interesting, is the awareness of these improvements by economic agents. We assume that to a large extent these productivity shocks came as a surprise in the mid-90 and led the private sector to revise upwards its growth expectation. However, by the end of 2000 such expectations proved to be partly ungrounded and were replaced by a more sober assessment.

Modelling agents' mistakes in a rational expectation model is not simple, and the way to do it cannot be uncontroversial. We model it by a sequence of unexpected additive shocks to total factor productivity (TFP). For 6 years TFP level is increased by 1% each year, and these increases were unanticipated. Afterwards, the reversal in expectations is rendered by a 1% decrease for 3 years, which however leave TFP some 3% above the baseline. Given the assumption on putty-clay technology, these shocks only affect newly installed production units, without changing old units' productivity.

In what follows we will explain the general effects of a permanent productivity shock and afterwards we will comment the effects of the particular assumptions we made about the dynamic of the shock we simulated.

### *3.1 Impact of a permanent productivity shock in the US on its economy (see the tables in Appendix B)*

The global productivity of both factors embodied in new production units is permanently increased by 0.25% in the United States (Hicks neutral shock). This increase was unanticipated by economic agents. An advantage of using a putty-clay specification is that the efficiency of old production units remains unchanged[11]. Thus, in the short run, there is a strong incentive for US firms to increase their investment, and for US households to consume more because of their higher anticipated wealth. As investment starts being productive the year after its installation, postponing or bringing forward the scrapping date of old production units is the only way to change potential output in the year of the shock. Thus, supply remains almost unchanged in the short-run, effective demand becomes higher than potential output and prices rise. The more usual putty-putty specification with disembodied technical progress such as the one used in Multimod and Quest, does not allow for this separation between the expansion of demand and the sluggishness of supply. Supply automatically and instantaneously increases with the rise in the global productivity of factors, which affects simultaneously new investments *and* old capital. In this case, and if investment is sufficiently sticky in the short run, the rise in productivity can increase supply more than effective demand and induce a fall in prices.

Hence, effective demand increases faster than potential output. This has two consequences. First, inflation increases quickly, then decreases at the speed at which potential output adjusts to demand. Second, the inflation rule followed by the Fed implies that nominal and

[11] The very rich putty-clay specification of the supply block of Marmotte allows for a wide range of productivity shocks. In this paper we will consider changes in the total productivity of new production units (Hicks neutral). It would be easy to simulate Harrod neutral or Solow neutral changes in productivity. We could also simulate the effects of shocks hitting old production units. In Marmotte, in every period a given proportion of firms goes bankrupt, victims of idiosyncratic shocks. This proportion can result from macroeconomic factors and can be changed for a simulation. In the cost of capital an exogenous risk premium is added to the interest rate. It can also depend on macroeconomic factors and be changed for a simulation.

real interest rates follow the same evolution. So, the real interest rate increases by 4.7 points in the year of the shock then decreases smoothly to 0.

The explanation of the next results of the simulation requires some modelling. All variables are in differences relative to the reference path of the model. Let $e$ be the exchange rate (i.e.; number foreign currency unit for a dollar), $p$ the price level in the US and $i$ the US interest rate. The variables at current time will have no index, the other variables will have an index representing their lead or lag. Index $\infty$ represents the long run. The first equation is the uncovered interest rate parity:

(1) $e = e_{+1} - i + kU$

This equation assumes that US' and other countries' short run assets are imperfect substitute. $U$ represents the US rate of foreign indebtedness, that is the value of US assets held by non Americans divided by US GDP. The assumption of non-substituability between national and foreign assets appears at this level. The variable risk premium was introduced in Marmotte to prevent foreign debt from diverging to infinity. When foreign debt becomes too high, everything else kept equal, then the US interest rate increases, which reduces absorption and improves the trade balance.

In the long run the exchange rate stabilises and the real interest rate becomes equal to the households' discount rate. It has the same value in the US as in other countries in Marmotte. So, we can deduce that $U_\infty = 0$: In the long run, the real interest rate and the rate of foreign indebtedness cannot change.

The second equation is the reaction function of the Fed:

(2) $i = 1.5(p - p_{-1})$

Let us substitute equation (2) in equation (1) and integrate forward:

(3) $e = e_\infty - 1.5(p_\infty - p_{-1}) + \int^{\infty} kU$

Let $er_\infty$ be the real exchange rate (e – p) of the dollar in the long term. Equation (3) becomes:

(4) $e = er_\infty - 0.5\,p_\infty + 1.5\,p_{-1} + \int^{\infty} kU$

In the long run, the higher supply of American goods on international markets will induce real depreciation of the dollar (by 0.48%). So $er_\infty > 0$. The transitory US inflation induces a permanent increase in the US production price (by 0.88%, the Fed has an inflation target which induces hysteresis in the values of nominal variables). So, the dollar depreciates in nominal terms (1.56% relatively to the yen, 1.25% relatively to the euro, and 1.21% relatively to the Canadian dollar).

At the date of the shock the price level starts from zero ($p_{-1} = 0$). So, the dollar should depreciate by 0.04% according to equation (4). The simulation shows that it depreciates a little more (by 0.15%, 0.19% or 0.27% according to the currency). The difference, which is moderate, results from the fact that the cumulative sum of the changes in net foreign assets is positive.

To conclude, from the time of the shock to the long run, the dollar depreciates smoothly from the first year to the long run. The American real exchange rate depreciates smoothly from 0.16% to 0.48%

Marmotte assumes perfect competition with free entry on the goods markets and constant return of scale in production. So, the model allows for the dual representation of technology in terms of a factor cost frontier. If the cost of capital did not move, the increase in the global productivity of factors by 0.25% would imply a higher increase in the productivity of labour and a still higher increase in the cost of labour[12]. Now, the factor cost frontier also establishes a negative relationship between the cost of labour and the cost of capital, that is the real interest rate. We saw that this last variable increases in the short run, then progressively returns to its reference value. So, finally, the cost of labour increases by 0.031% the year of the shock. Then it progressively increases toward its new long run value of 0.339%.

The lifetime of capital in Marmotte is a little more than 40 years. Thus, over this time firms hold new capital, which has benefited of the increase in productivity, and old capital, which was installed before the positive productivity shock and is unaffected by it. Over these 40 years the age when the old capital is scrapped decreases over time: An old production unit is scrapped when its profit over variable costs (labour costs) becomes zero. As the real cost of labour progressively converges toward its higher path, old production units turn unprofitable sooner and sooner. Of course when there are no more production units installed before the time of the productivity shock, the lifetime of the old capital almost comes back to its pre-shock level (actually it decreases a little bit for reasons which will be given later).

Investment increases quickly and strongly (by 0.46% two years after the shock). Then, it progressively decreases to a lower level. The capital intensity of new production units depends on the ratio between the cost of labour and the cost of capital[13]. In the long run, the first cost will increase strongly. The cost of capital depends on the real interest rate, which will come back in the long run to its pre-shock level, and on the price of capital relative to US production price, which will increase because the US real exchange rate depreciates. However, in the long run the first increase is higher than the last and the capital intensity of new production units is higher than before the shock. In the short run the increase in the cost of labour is weak. But the real interest rate increases and the rise in the relative price of capital is quick. So, the capital intensity becomes lower than before the shock. Then, progressively it increases.

So, new production units in the years following the shock will be relatively labour intensive. This choice will shorten its expected lifetime: investment will become unprofitable sooner because of the progressive increase in labour costs. So the investment made in the year of

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[12] With a CES production function of elasticity of substitution $s$, if we denote as $w$, $r$ and $p$ the cost of labour, the real interest rate and the relative price of capital, and by $z$ the total productivity of factors, the factor cost frontier is: $1 = z^{s-1}[a^s (rp)^{1-s} + (1-a)^s w^{1-s}]$. We see that an increase of $z$ by 0.25% when the real interest rate and the price of capital do not move, will imply an increase in the cost of labour higher than 0.25%. In the long run the price of capital increases but at a too a small extent to change this result. Moreover, the equality between the marginal productivity of labour and its cost implies that: $w / z = (Y / Lz)^{1/s}$. As we assume in the calibration of the model that $s < 1$, we conclude that the productivity of labour increases by more than the total productivity of factors but by less than the cost of labour. Of course, this equation is only valid with a putty-putty technology, but it is still a good reference to interpret our results.

[13] If $K$ and $L$ represent capital and employment, we have: $[(1-a)/a](K/L)^{1/s} = w/rp$. Actually, this equation is only valid with a putty-putty technology. With a putty-clay technology it should include the forecasts of its variables over the whole lifetime of the new production unit. However, as in the previous footnote, this equation is a good enough approximation for obtaining a correct interpretation of the results of the simulation.

the shock will have a shorter expected lifetime than units built before the shock. This shortening of the lifetime of new investment will decrease over time. However, in the long run, as the cost of labour will have increased by more than the global productivity of factors, the lifetime of investment will be under its pre-shock value. In the long-term, the world economy is on a steady state and the lifetimes of all the capital vintages are equal (and shorter than before the shock).

We saw that the real cost of labour increases progressively. Moreover, in the long run it increases by more than the productivity of labour. These evolutions attract more and more workers to firms (the wage curve can be interpreted as a pseudo-supply of labour, with a positive relationship between employment and the real wage rate). So, employment will increase progressively. The real cost of labour is computed on a legal year. However, the wage curve is based on an assumption of overlapping contracts, which induce nominal wages stickiness, and the real cost of labour for a contract differs from the real cost of labour computed for the year when the contract started. For the first years of the simulation the first cost decreases and employment is under is baseline value

Potential output reflects the movement in employment, in the scrapping dates of old production units and in the capital intensity of new units. It decreases a little bit in the year of the shock, then increases smoothly afterward.

Households determine their consumption in function of their permanent income. As it has instantaneously increased the year of the shock, consumption should do the same. However, the movements in the real interest rate and the habits of households, which do not like changing their consumption too quickly, correct this evolution. So, consumption decreases a little bit in the year of the shock, then increases smoothly and is 0.31% over its baseline value in the long run.

The movement in US exports is driven by the real exchange rate. These exports progressively increase, by 0.05% in the short-run and by 0.36% in the long run. The real exchange rate and US activity drive the movement of US imports. The second effect slightly dominates most of the time and imports increase by 0.02% in the short-run and by 0.04% in the long term. Moreover, the depreciation of the dollar drives a progressive increase of the prices in dollars of imports and exports, slightly stronger for the price of imports Finally, the deficit of the trade balance increases in the short-run. Then it decreases over time, disappears in the middle-run, and turns into a surplus.

In the short run, the temporary increase in the short-run interest rate creates a capital loss on long-term assets. So the public debt of the US Government and US liabilities on foreign countries decrease. The relative sluggishness of potential output, due to the putty-clay structure, causes strong demand effects which explain that this productivity shock does not have the effect usually found for supply shocks.

### *3.2 Impact of a US permanent productivity shock on the other countries*

The imports of the three investigated countries or zones reflect US exports and increase significantly. Their exports reflect the increase in US imports, but also their loss of competitiveness relatively to US exports on all markets. So, their movements are weak around their baseline values. The trade balances are expressed as a percentage of GDP. They present a small surplus in the short run because of the decrease in the cost of imports resulting from the depreciation of the dollar, then turn into a deficit.

The appreciation of the real exchange rates of the three countries or zone implies that consumption and investment prices will increase by less than production prices and than the wage rate. So, investment becomes relatively cheap and households' purchasing power rises. So

investment and consumption increase in the medium run. This increase is progressive for consumption because of households' habits. It is immediate for investment. However, the dynamic paths of both variables are sensitive to the real interest rate and to the real exchange rate.

As in the US, effective demand increases more than potential output in the three countries or zone, so their prices increase. However, since the euro, the yen and the Canadian dollar appreciate progressively, the inflation rates for consumption and investment are much lower than for production. As monetary policies are based on consumption inflation, nominal interest rates increase only slightly. The real interest rates, which are given in the tables, are relative to the inflation of the production price. This explains why they can be below their baseline levels, at least in the first years of the simulations, for Europe and Japan. In the long run real and nominal interest rates progressively come back to their pre-shock levels.

The factor cost frontier shows that the dynamics of the cost of labour is the symmetric of the dynamics of the cost of capital. This last cost is proportional to the real interest rate and decreases when the real exchange rate appreciates. The movements of these two variables compensate in the short and medium run and the cost of capital does not move at this horizon. However, the cost of capital decreases in the long run, when the interest rate has come back to its reference value. So, the cost of labour does not move much in the first year of the simulation, but it increases in the long run. The real wage rate increases more than the cost of labour because of the real appreciation of the exchange rate. This movement attracts manpower and employment progressively increases. As the relative price of capital progressively decreases, the capital intensity of new production units increases progressively.

To compare how the spill over of the US shock differs between large countries (the Euro zone and Japan) and small countries (Canada) we will use a very simple theoretical model. We will consider a world of two countries denoted 1 and 2. The size of the world is $S$, and the sizes of the two countries respectively are $lS$ and $\overline{l}S$, with $\overline{l} = 1 - l$. We will assume that country 1 is larger than country 2, that is $l > 1/2$. Each country produces a specific good, and each country consumes both goods. We will start by assuming that the supply of each good is fixed, and is equal to the size of the country, which produces it. According to Walras' law, we will only have to look at the equilibrium of the market of the first good. We will denote as $p$ the price of the second good in terms of the first one, which will be used as numeraire. $e$ will represent the price elasticity of demand for the first good which is common to both countries. We will assume that the share of consumption allocated to one of the goods is proportional to the size of the country producing this good. So, the real income of country 1 is $lS$ and its demand of good 1 is $l^2 Sp^e$. The real income of the second country is $\overline{l}S$ and its demand of commodity 1 is $l\overline{l}Sp^e$. So the equilibrium of the market of good 1 is:

(5) $lS = l^2 Sp^e + l\overline{l}Sp^e$

The solution of this equation is $p = 1$. Now, we will increase the production of country 1 proportionally to its size, by $l dS$. By differentiating equation (5) we obtain the associated move in price:

(6) $dp = -(\overline{l}/e)dS/S$

When: $p = 1$, the shares of total consumption allocated to goods 1 and 2 are respectively $l$ and $\overline{l}$, in each country. That means that the share of a good in consumption is equal to the size of the country that produces this good divided by the size of the world. So the price of

consumption in both countries is $p^{\bar{T}}$. The terms of trade of countries 1 and 2, defined as the ratios of production price to consumption price, are respectively $p^{-\bar{T}}$ and $p^{\bar{T}}$. When this term of trade increases in a country, we will assume that its cost of labour decreases, its real wage rate increases and its employment increases. Now we can correct our initial assumption and assume that when employment increases, output increase too. We have the following proposition.

*Proposition. When a positive productivity shock occurs in country 1, the relative price of country 2 good, the term of trade of this country, its real wages and its employment increase. Its cost of labour decreases. The changes in the previous variables in country 2 decrease with the relative size of this country, and tend to 0 when country 2 is very small.*

This proposition explains why, as long as exchange rates are concerned the spill over of the US productivity shock is higher for Japan and the Euro zone than for Canada. Country size is the key factor

We chose to limit the place where the productivity shock occurred to the US, at the exclusion of Canada because the production structure is very different between Canada and the US. Canada includes little high tech sectors, but it is a net supplier of raw materials, especially gas and oil. Under these circumstances, the flexibility of the Canadian exchange rate deals with the asymmetric shock of this paragraph quite well. A positive productivity shock in the US leads to an appreciation of the real exchange rate of Canada. This movement is accommodated by a higher nominal appreciation of the Canadian dollar, which allows a quasi-stability of prices in Canada: the consumption inflation hardly moves, and the production inflation increases only in the first year.

We can conclude this section by noticing that 5 years after the productivity shock in the US, GDP has increased by 0.154% in the US, 0.036% in Japan, 0.036% in the Euro-zone and 0.032 in Canada. Thus the spill over is quite important, and will still be higher in the long run.

### *3.3The impact of repeated productivity shocks and the treatment of expectations*

We will now assume that the US is hit by permanent positive productivity shocks in years 1, 2,.. and 6. Each of these shocks increases the global productivity of factors embodied in new production units by 1%. However, in year 7, the technological environment of the US changes and is hit by a negative 1% permanent productivity shock. Other negative shocks of the same size hit the US economy in years 8 and 9. Therefore, agents first raise their growth expectations during the first seven years, then lower them abruptly for three more years before stabilising, as depicted in Figure1. This scenario attempts to reproduce the acceleration of the US economy in the nineties, followed by its slowing down in more recent years. Then, we face the following question: at which extent was this series of shocks anticipated by economic agents in year 1, or afterward? We can reasonably assume that the economic slow down, which started in year 7, was not expected before. However, for how long was the acceleration of the growth rate, which started in year 1, expected to last? We will see in Appendix A that if this acceleration had been correctly anticipated, firms would have postponed their investment in the short run: for their total lifetime these investments would have been stuck in technologies less efficient than those which will be available a few years later.

Models assuming putty-putty technology with disembodied technical progress, cannot catch this mechanism: all capital immediately integrates technological improvements, so there is no reason to postpone investment when these improvements are assumed to take place in the future. So, we will assume that each of the changes in productivity was *unanticipated* before it takes place. The charts (from Chart 1 to chart 7) represent the relative difference between the simulation of this scenario and the baseline of Marmotte.

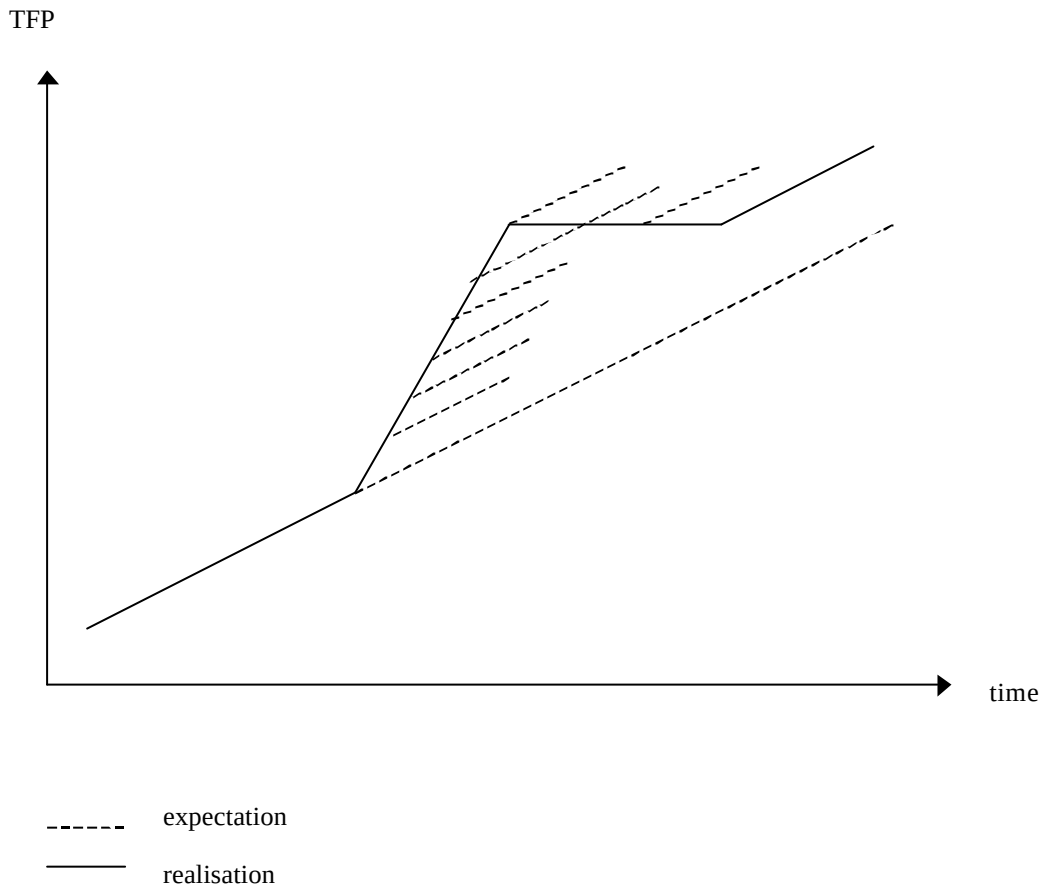


Figure 1. US Total Factor Productivity: expectations and realisation

Relative to the baseline the main results are the following:

- GDP, investment and inflation increase steadily for 6 years, then decrease for the three following years. However, consumption in the US stays under its baseline value for the 6 years of expansion because it is crowded out by the high level of investment in this country.
- Because of the wage stickiness resulting from a system of collective bargaining in overlapping contracts, the US real wages and employment pass below their baseline values in the expansion period, then increase afterward.
- The US trade balance deteriorates at a decreasing rate for the 6 years of positive shocks. Then, it progressively improves and quickly passes above its value of the baseline. The euro, the yen and the Canadian dollar appreciate relatively to the dollar for 6 or 7 years, then they stabilise.
- The spill over of the US shocks to other industrialised countries is quite strong.

This simulation of Marmotte reproduces well the US expansion from 1994 to 1999, then the slow down, which followed in 2000, 2001 and 2002, the only exception being private consumption. However, there are three contradictions between the results of the simulation and the situation observed in the US: employment increased from 1993 to 2000, then decreased a little bit in 2001; the Canadian dollar and the euro depreciated smoothly since 1995(until 2001 for the euro); the deterioration of the US balance of trade started in 1998, so at a late stage of the expansion period, but continued after the US slowdown. Moreover, the observed series exhibit a decrease in the inflation rate during the slow down of the US economy, but no increase in this rate during expansion years.

### *4. Risk premium shock*

The second scenario considered is an increase in the risk premium of Canada, the Euro zone and Japan relative to the United States such as it appears in the interest rate parity equations of the three first countries or zone. This means that lending to the US has become safer than lending to the other countries, everything else kept constant. We will start by assuming that at time 1 investing in the US suddenly appears less risky than investing in Canada, Europe or Japan. This change of opinion is assumed to be permanent. Then, we will assume that the opinion of financial markets builds up in six consecutive years. Afterwards, a reversal in expectations is rendered by a decrease in the risk premium for the next three consecutive years. So, this scenario tries to catch the increasing attraction of the North American financial markets in the nineties, followed by a revision in this opinion for the following years.

### *4.1 Effects of a permanent risk premium shock (see Table in Appendix C)*

An exogenous risk premium of 0.1% is added to the variable risk premiums in the three uncovered interest rate parity equations of Canada the Euro zone and Japan. This means that lending to the US has become safer, everything else kept constant. In the long run, the real interest rate in each country is equal to the households' discount rate, which is the same in the four countries or zone. Thus, the increase in the exogenous risk premium must be compensated by a decrease in the endogenous risk premium. This means that the rate of foreign indebtedness must increase in the US and decrease elsewhere. The first movement will result from a transitory trade deficit of the US, which will turn into a surplus in the long run to finance the higher interest cost of foreign debt. The opposite movement will take place in Canada Japan and in the Euro zone.

The US trade deficit in the short and the medium run results from the real exchange rate appreciation (by 0.31% in the first year). As production prices increase, for reasons given later, the US dollar appreciates still relatively to the euro, the yen and the Canadian Dollar (respectively by 0.21% , 0.27% and 0.20% in the first year). However, in the very short run, trade flows will present some inertia. So, the US trade balance exhibits a surplus in the first year. This is nothing else than the J curve mechanism.

The US imports increase progressively in the short and medium run, then progressively decrease below their baseline level. The US exports have the opposite evolution. This entails a marked short run increase in investment. The dynamic profile of investment in the short run is more driven by the real exchange rate (which appreciates very much at time 0, which decreases the cost of capital) than by the real interest rate. In the long run it comes back to its initial level. Employment and potential output follow the same expansion, then decrease alongside with capital in the very long run. The US trade surplus in the long run results from the 0.065% depreciation of the real exchange rate. Therefore, the cost of capital decreases in the short run and increases in the long run. Thus, capital intensity increases in the short run and the expansion of potential output is higher than the one of employment. We get the opposite result in the long run.

In the long term the real depreciation of the dollar pushes the cost of capital up. Then, the factor-cost frontier establishes that the cost of labour decreases. The real wage rate follows this movement, which reduces the supply of labour and employment is down. Thus, in the very long term US activity is below its baseline level. As the United States will be poorer, household consumption will also be below its reference level. However, the decrease in the real interest rate and the short run appreciation of the real exchange rate will drive an expansion of consumption in the short and medium run, followed by a decrease to its depressed long-run level. Actually, if

American households will be poorer in the long run, they become wealthier at the time of the shock, and their welfare increases at this time.

In the short run, consumption and investment increase in the US. However, exports decrease and imports increase. Finally, after year 0, we find that the demand for the US good increases a little less than its potential output, and inflation decreases (by 0.022% in year 1), before coming back to its reference level. The production price decreases by a decreasing rate, before stabilising at about –0.22%. The movement in inflation is reflected in the nominal and real interest rates.

Results for the other countries are almost exactly opposite to those for the US.

### *4.2 The treatment of expectations*

In this scenario we assume that Canada, the Euro zone and Japan are hit by 0.4% permanent risk premium shocks in each year 1, 2,.. and 6 of 0.4%. However, in year 7, the perception of risk by financial markets changes and these economies are hit by opposite permanent risk premium shocks in each year 7, 8 and 9 of -0.4%. Moreover, we assume that each of these 9 shocks was unanticipated. Indeed, we have assumed the same timing and structure in the revision of agents' expectations as in the productivity shock scenario. The change from increasingly bullish to bearish expectations causes a break in the path of the series.

The graphs (from charts 8 to 14) represent the relative difference between the simulation of this scenario and the baseline.

Relatively to the baseline, the main results are the following:

- In the US, GDP, consumption, investment and employment increase steadily for 6 years, then decrease for the following years. From the seventh year on, investment declines strongly but does not collapse. Contrary with the productivity shock, the change in GDP is almost immediate, at the beginning of the expansion or the recession period. Canada the Euro zone and Japan have the opposite evolution.
- The employment in the US increases steadily for 6 years then decreases. So, this scenario is more in line with what happened in the US than the productivity scenario.
- Consumption price inflation decreases progressively in the US during the expansion period, then comes back to its previous level progressively. The evolution is opposite in the other countries. As in the case of trade balance, the effect is much stronger in Canada.
- US trade balance deteriorates for 6 years, then improve. In the other countries the evolution is opposite. Thus, the two scenarios can explain the deterioration of the US balance but not its worsening afterward.
- The euro and the yen depreciate relatively to the dollar for 6 years, then they appreciate. The exchange rate of the Canadian dollar exhibits a similar dynamic but with a much smaller amplitude, due to the differences in trade patterns and economic size.

Summing up, we can observe that the dynamic of the variables is qualitatively the same in Canada as in Europe and Japan. However, in Canada the amplitude of the movement is especially weak for the real variable and the exchange rate. On the contrary, the trade balance and prices show a much higher volatility. This result can still be explained by the relatively small size and strong openness of the Canadian economy.

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This simulation of Marmotte reproduces well the US expansion from 1994 to 1999, then the slow down, which followed. The acceleration of the expansion period is less marked in this simulation than in the previous one, and is more consistent with what happened. We have the same similarities with what happened for the exchange rates and the balance of trade. However, we still have several contradictions between the results of the simulation and the situation observed in the US: The deterioration of the US balance of trade started at a late stage of the expansion period,

but continued after the US slowdown. The observed series exhibit a decrease in the inflation rate during the slow down of the US economy, but no increase in this rate during expansion years.

By combining the two simulations we can expect to obtain a depreciation of the non-US currencies, a stabilisation of inflation and realistic paths for GDP, consumption, investment and employment.

***5. Combination of the two shocks***

To have a complete picture we finally simulated both combinations of shocks at the same time, as it is likely that they occurred at the same time. The results (Graphs 15 to 21) are more realistic than those in the two shocks simulated in isolation.

Relatively to the baseline, the results are the following:

In the US, GDP, consumption, investment, employment and inflation increase steadily for 6 years, then decrease for the following years. The evolution of the employment is in line with what happened in the US.

- US trade balance deteriorates for 6 years, then progressively improves. Thus, this scenario can explain the deterioration of the US balance but not the its worsening afterward.
- The euro, the yen and the Canadian dollar appreciate progressively relatively to the dollar.
- *The spill over to other industrial countries is strong, particularly for Canada where it is expansionary.* However, we must remember that the effects of the risk premium shock on non-US economies are, in general, opposite to the effect of the productivity shock. This simulation of Marmotte reproduces well the US expansion from 1994 to 1999, then the slow down, which followed. It also reproduces the deterioration of the US balance in the expansion period well, but it cannot explain why this deterioration happened so late and why this deterioration persisted afterwards.

We have the same similarities with what happened for the exchange rates and the balance of trade. However, we still have several contradictions between the results of the simulation and the situation observed in the US: The deterioration of the US balance of trade started at a late stage of the expansion period, but continued after the US slowdown. The observed series exhibit a decrease in the inflation rate during the slow down of the US economy, but no increase in this rate during expansion years. Our simulation is unable to reproduce the appreciation of the dollar during the expansion period.

***Conclusion***

In this paper we have attempted to explain some stylised facts, which took place in the US over the last years by using a structural multinational model and by hitting this model with a small number of basic shocks. The combination of these shocks allows for a good understanding of what happened in the United States and of the spill over of business conditions in the US to other industrialised countries. However, we have been unable to explain why the current bad conditions in the US and the depreciation of the dollar have coincided with some deterioration of the US trade balance: a plausible explanation could be that the still strong consumption growth is fuelled by factors such as the boom in housing prices, which cannot be captured by models such as Marmotte.

There are two advantages in using a structural model to investigate the effects of shocks. First, the nature of the shock is defined with much precision. For instance, here we considered a Hicks neutral improvement in the productivity of new production units. Many other supply shocks could have been defined in the model Marmotte, and their economic effects would probably have been different. The second reason is that the transmission channels of the shock are perfectly precise and clear.

A limit of structural models is that they are likely to omit some channels, which are important but badly understood by theoretical and applied macroeconomics. In general, structural VAR models conclude to stronger international diffusions of national shocks than structural models. However, this limit does not prevent the spill over of the US productivity shock and of the Canadian, European and Japanese risk premium shock of being quite important in Marmotte.

Putty clay technology increases the simulation time of the model because it introduces a high number of leads and lags in the equations. On the other hand it allows for much more precision in the definition of a productivity shock by separating old and new production units. It also introduces sluggishness in the diffusion of technical progress, which is reasonable and allows for convincing medium run dynamics. It gives a specification of the labour market in terms of hiring and firing flows. It also induces some inertia in the response of investment to changes in the interest rate. All in all, it probably provides a more realistic description of investment dynamics without having to assume *ad hoc* features such as convex building and installation costs.

For both unanticipated shocks investigated here, in the short run, the ratio of US production to European production increases. However, with the production shock we get a nominal and real appreciation of the euro. For the risk premium shock we get a real and nominal depreciation of the euro. This last result is similar to the one given by the Balassa-Samuelson effect. However, the mechanism is completely different. Indeed an explanation partially based on this effect, like the one contained in Hunt and Rebucci (2003), which does an exercise similar to ours, is quite successful in understanding the dynamics of the dollar exchange rate.

**References**

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Cadiou Loïc (2001), Stéphane Dées, Stéphanie Guichard, Arjan Kadareja, Jean-Pierre Laffargue and Bronka Rzepkowski (2001), "Marmotte. A Multinational Model by CEPII and CEPREMAP", *CEPII Working Paper* n° 15, available on the website: www.cepii.fr .

Cadiou Loïc, Stéphane Dées and Jean-Pierre Laffargue (2002) "A Computational Model with Vintage Capital", *Journal of Economic Dynamics and Control"*.

Charts

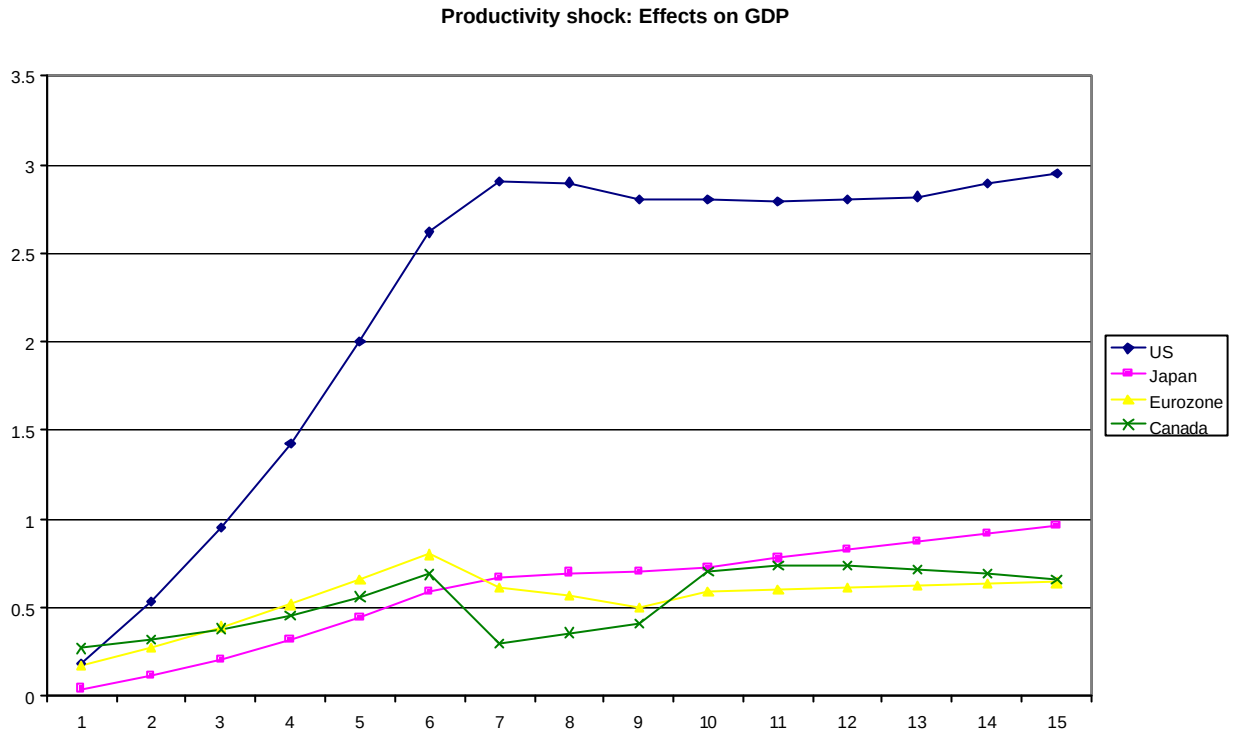



Chart1: US productivity shock, effects on GDP (% deviation from baseline)

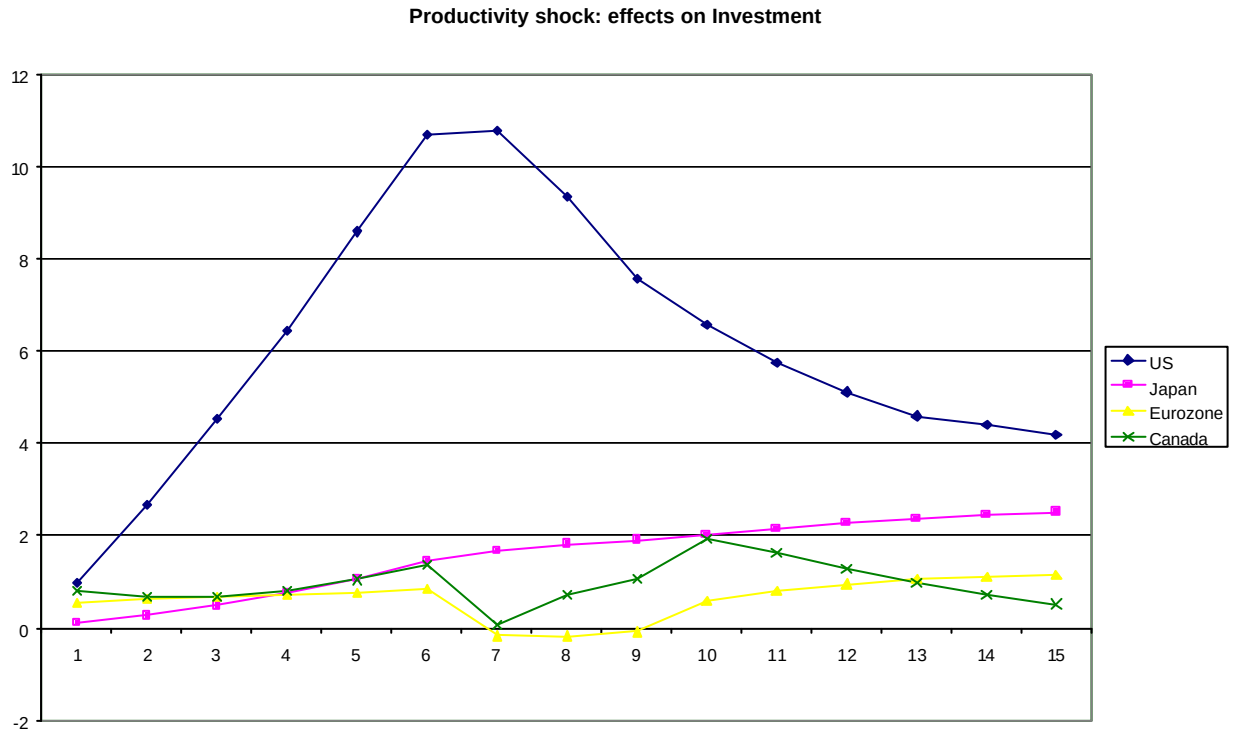



Chart 2: US productivity shock, effects on Investment (% deviation from baseline)

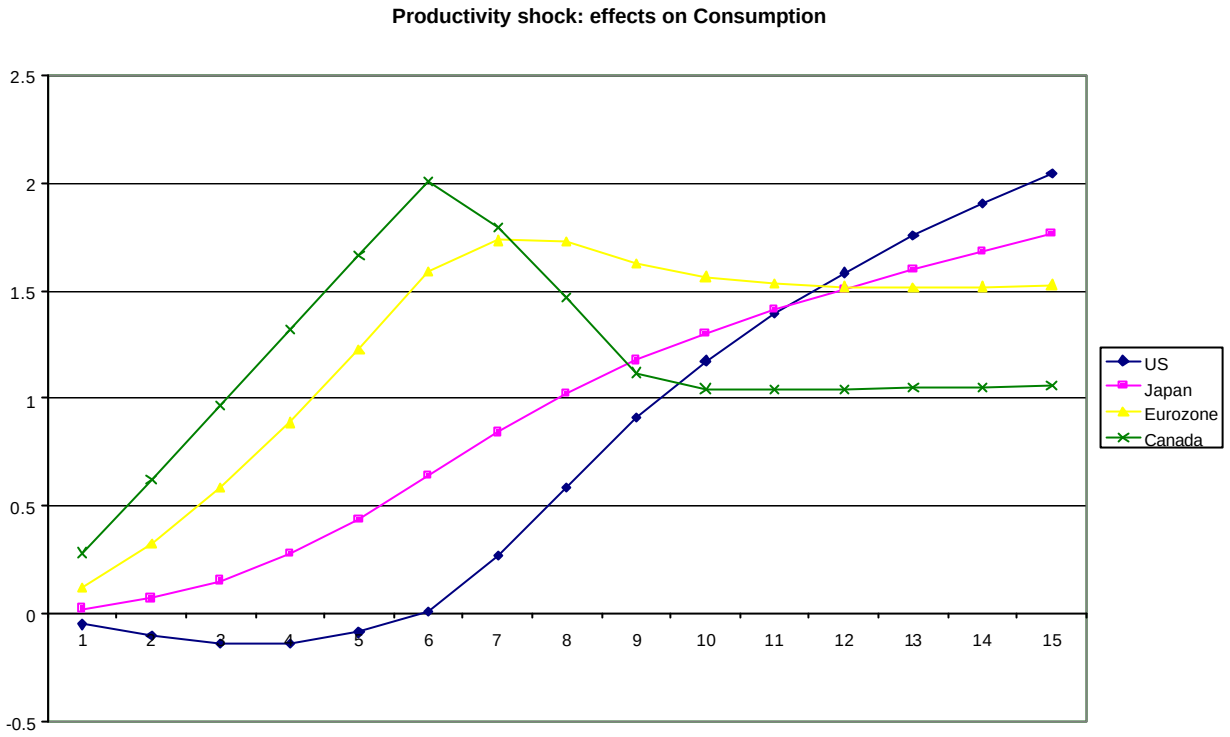



Chart 3 : US productivity shock, effects on Private Consumption (% deviation from baseline)

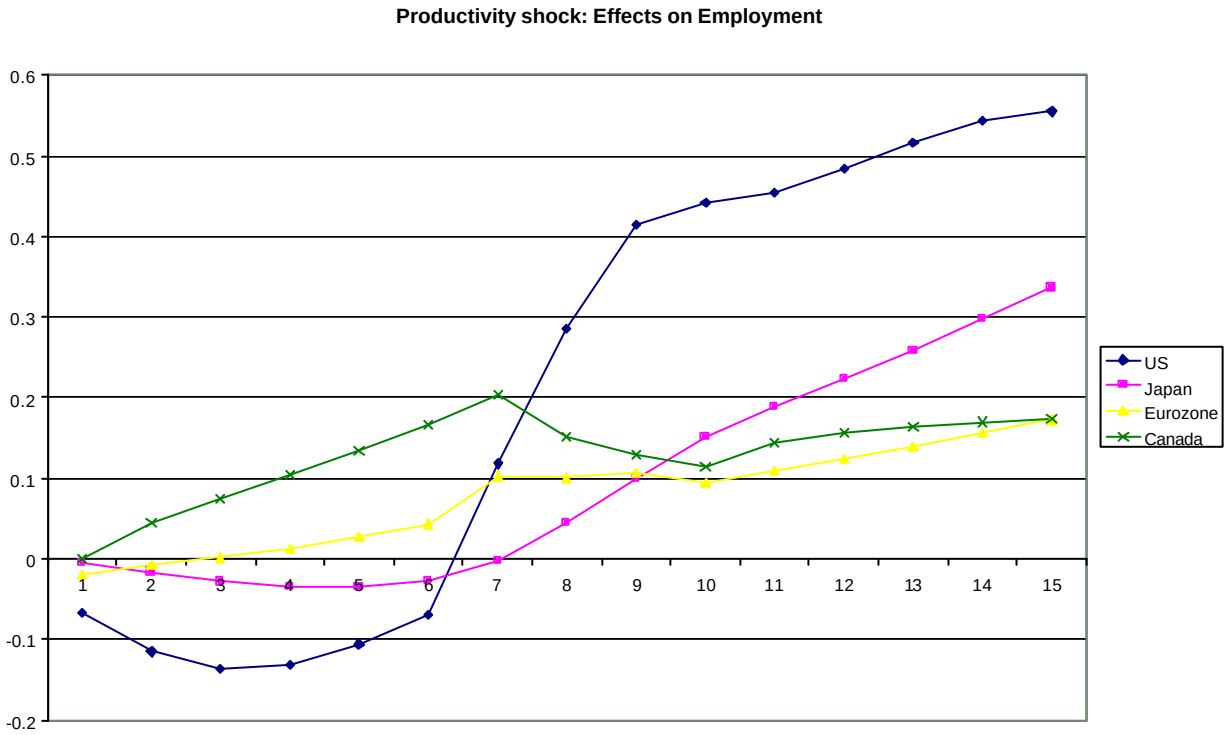



Chart 4 : US productivity shock, effects on employment (% deviation from baseline)

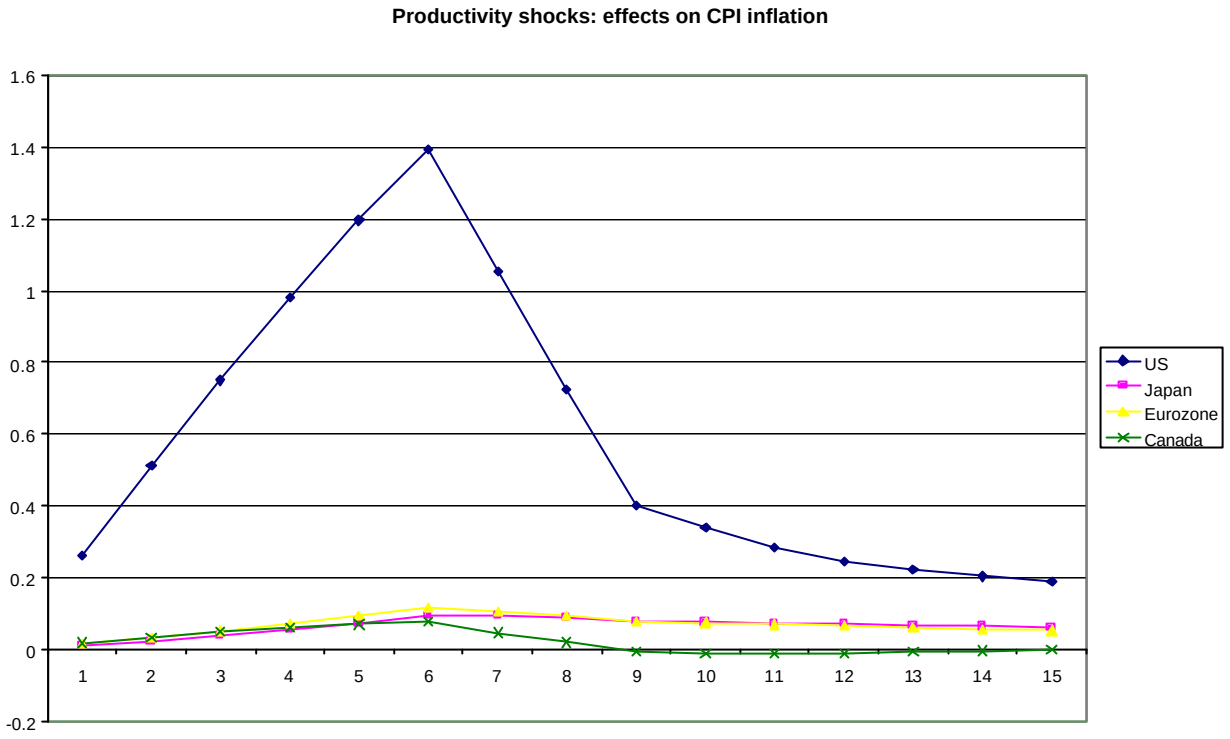



Chart 5: US productivity shock, effects on CPI inflation (absolute deviation from baseline)

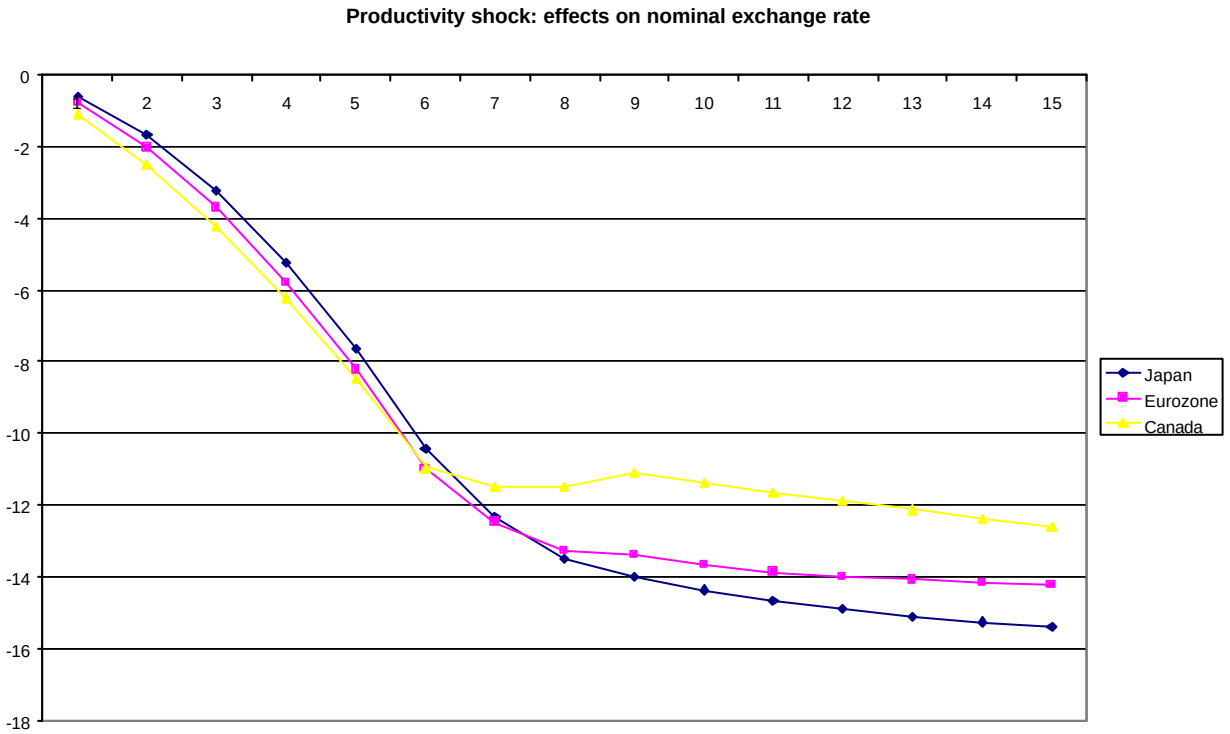



Chart 6: US productivity shock, effects on nominal exchange rate vis-à-vis the US dollar (% deviation from baseline)

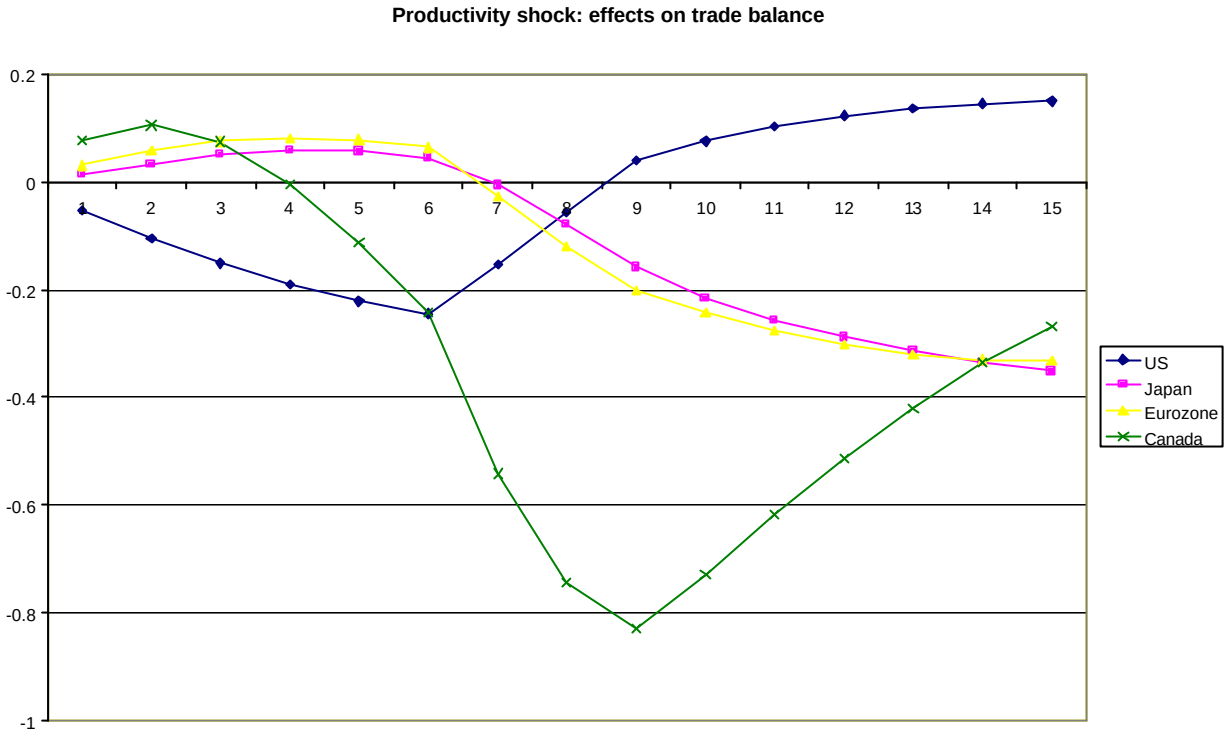



Chart 7: US productivity shock, effects on trade balance to GDP ratio (absolute deviation from baseline)

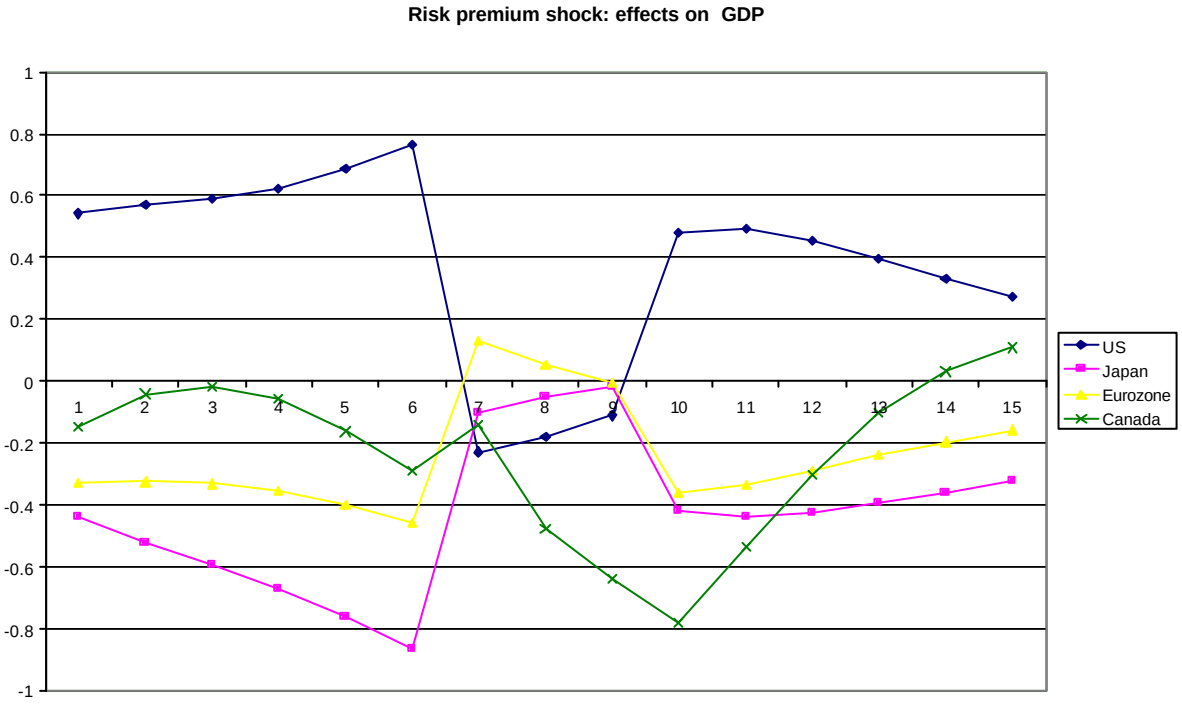



Chart 8: Risk premium shock, effects on GDP (% deviation from baseline)

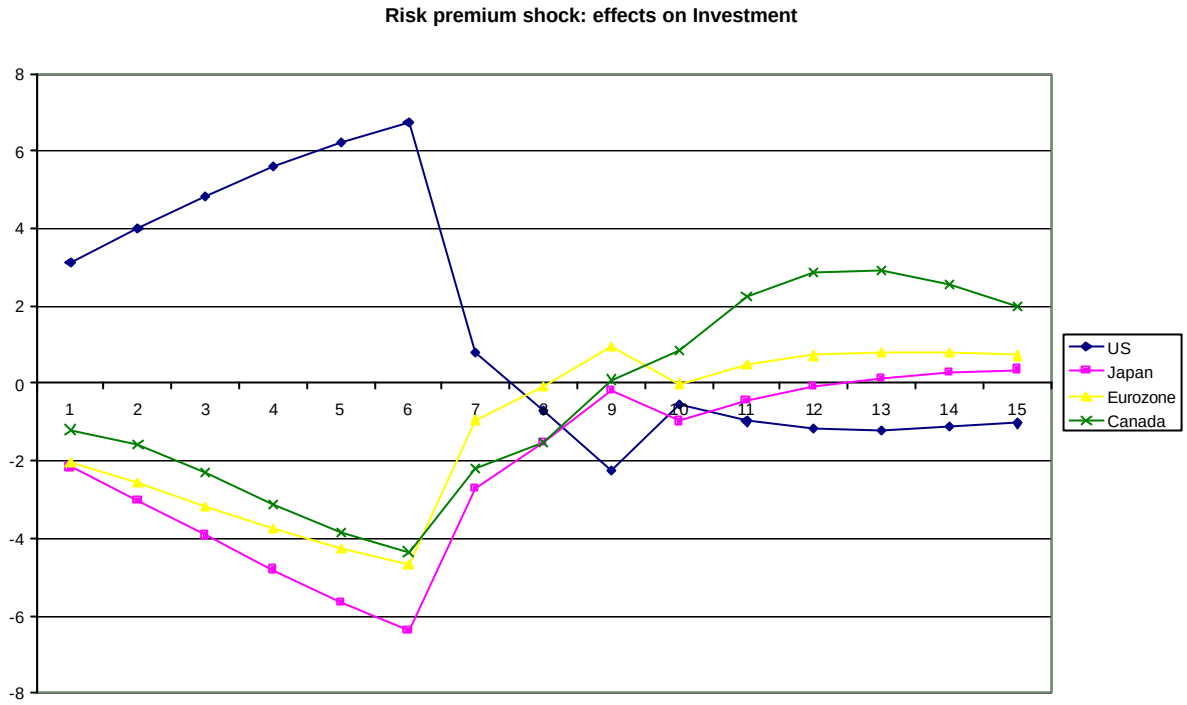



Chart 9: Risk premium shock, effects on Investment (% deviation from baseline)

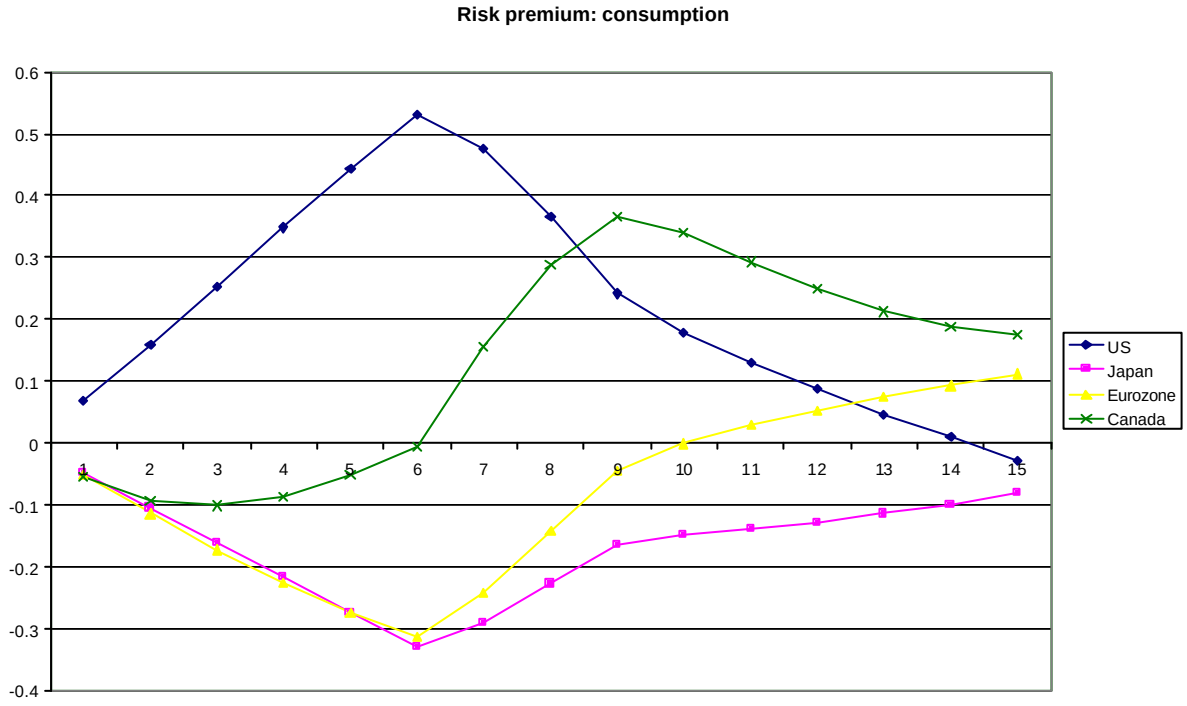



Chart 10: Risk premium shocks, effects on consumption (% deviation from baseline)

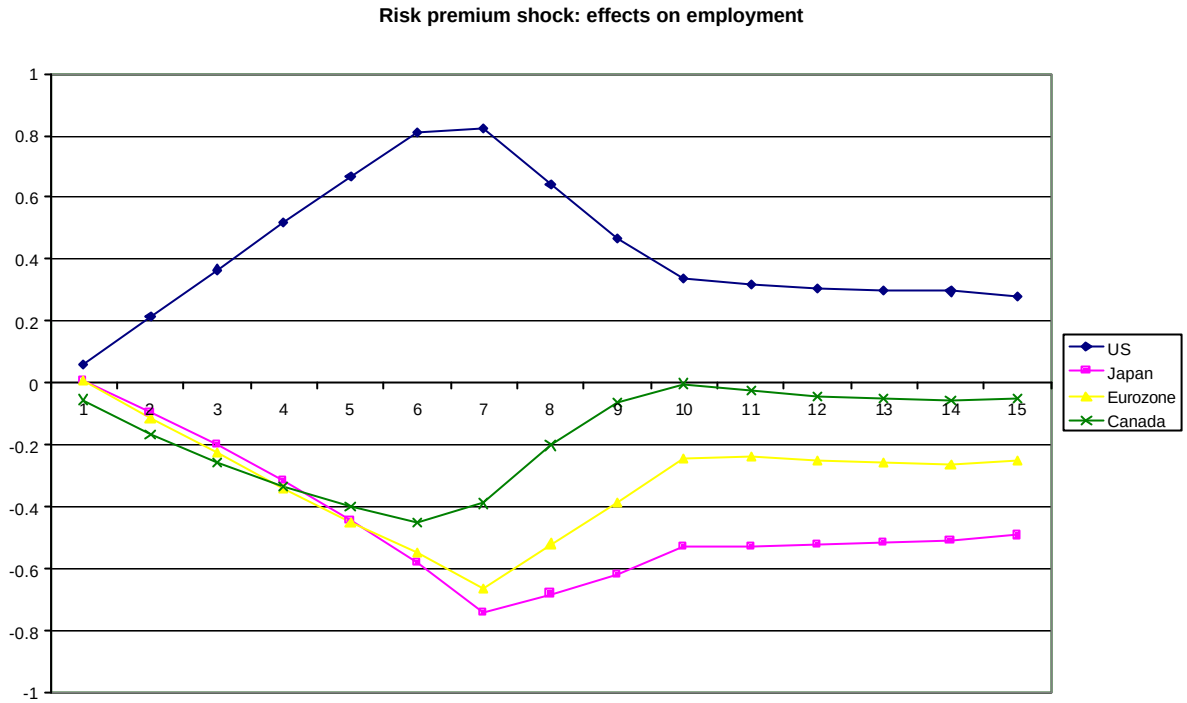



Chart 11: Risk premium shock, effects on employment (% deviation from baseline)

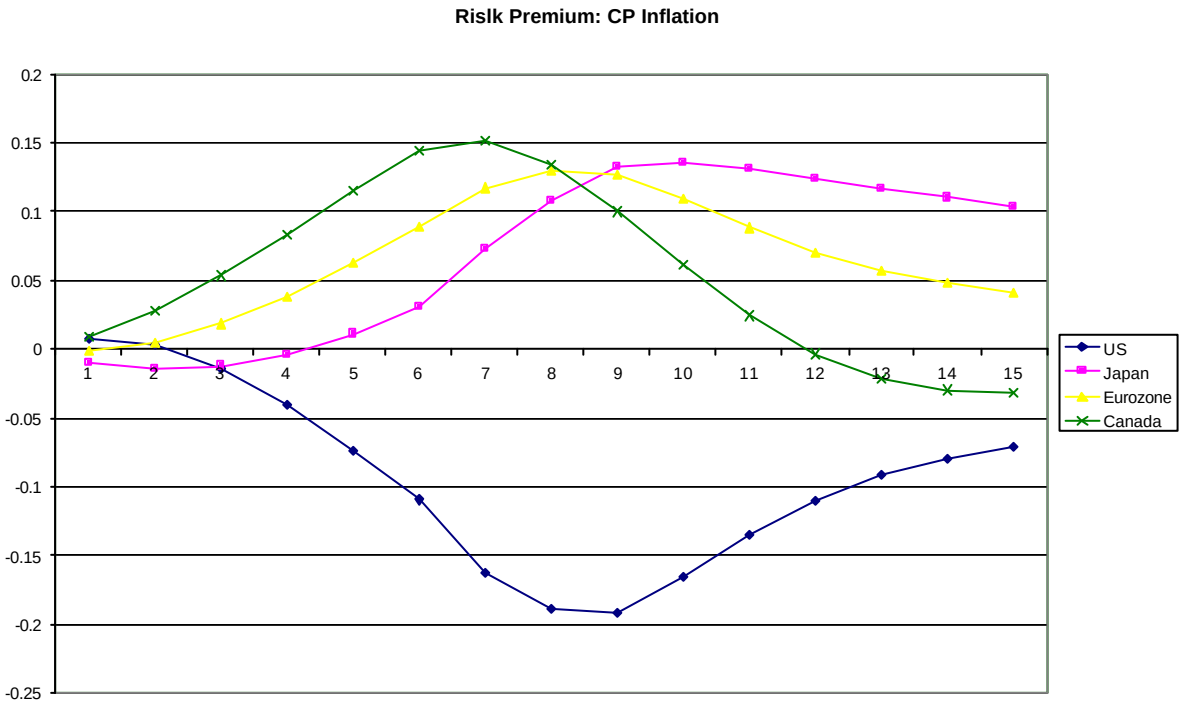



Chart 12: Risk premium shock, effects on CPI inflation (absolute deviation from baseline)

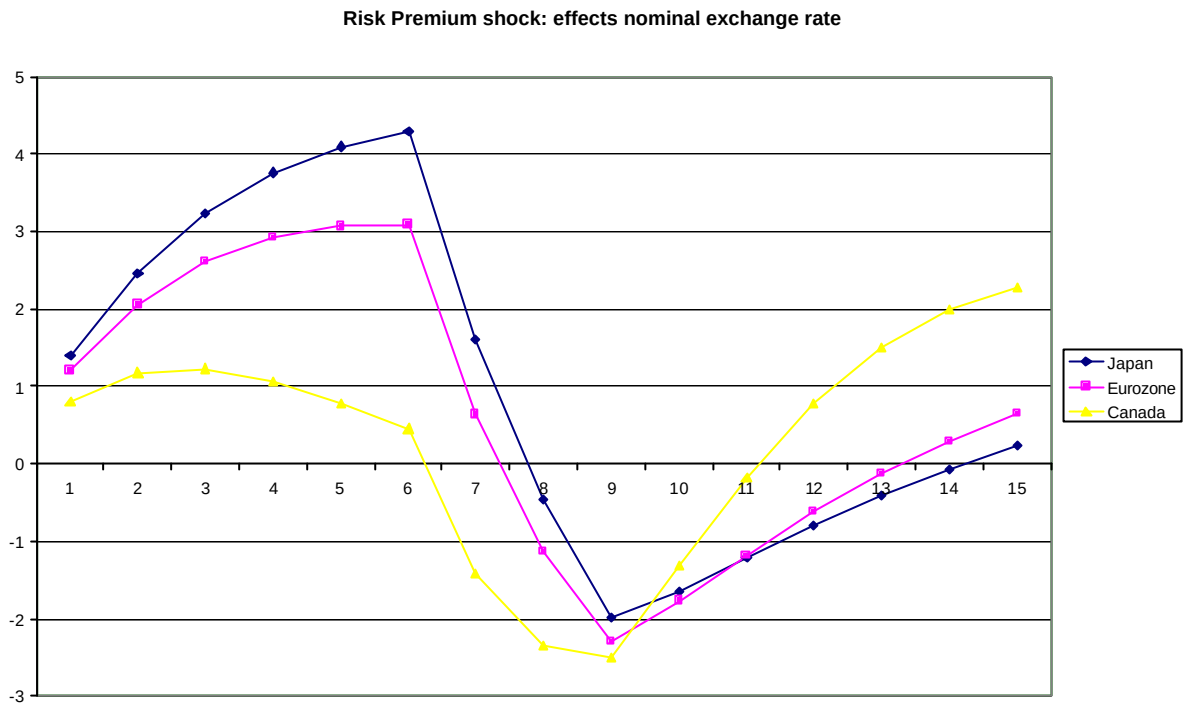



Chart 13: Risk premium shocks, effects on nominal exchange rate (% deviation from baseline)

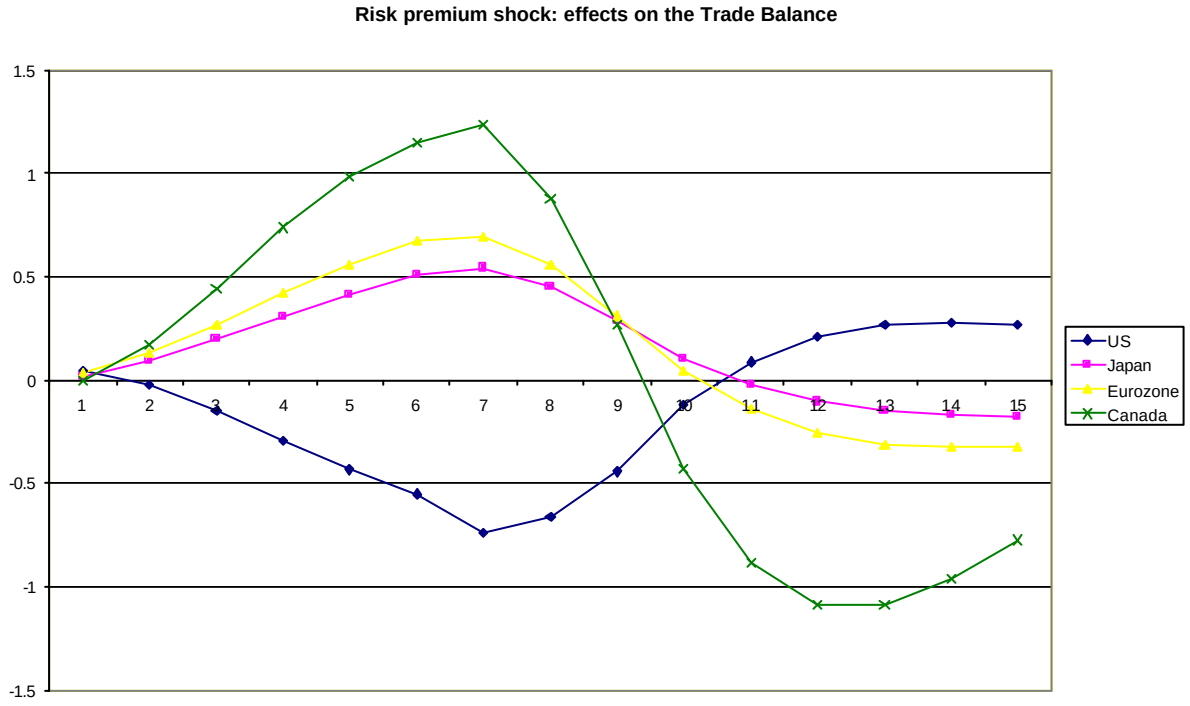



Chart 14: Risk premium shock, effects on the trade balance to GDP ratio (absolute deviation from baseline)

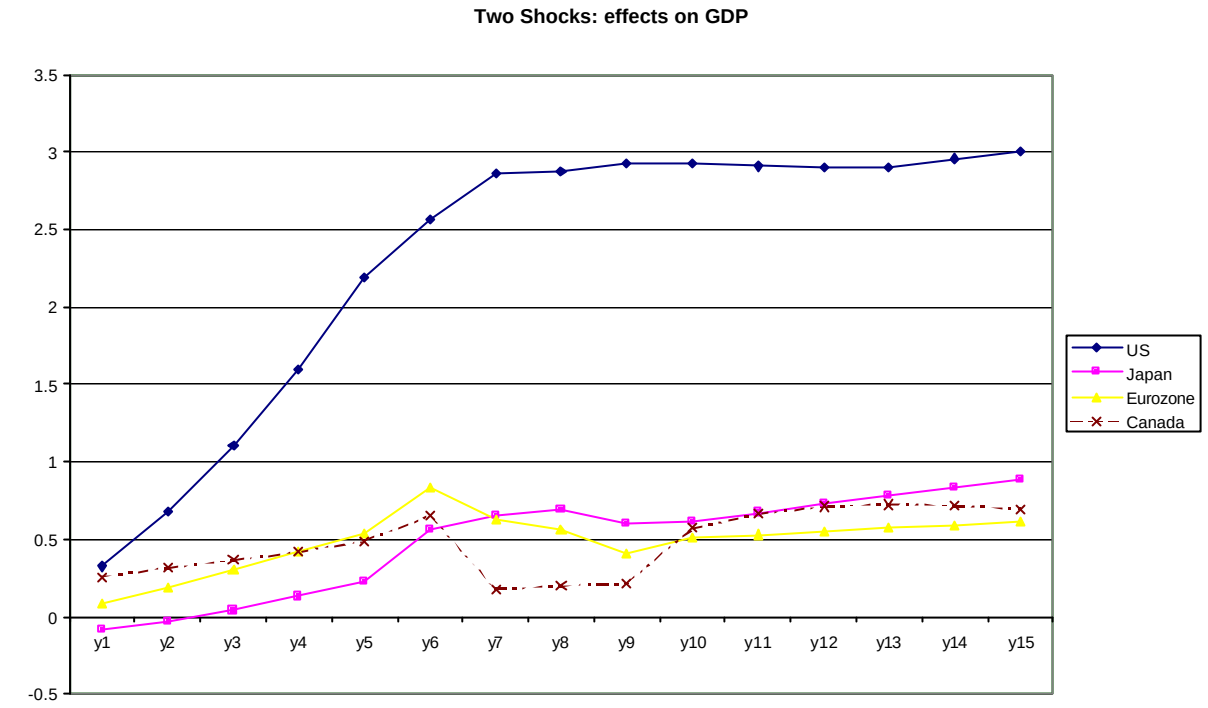



Chart 15: Combination of the two shocks, effects on GDP (% deviation from baseline)

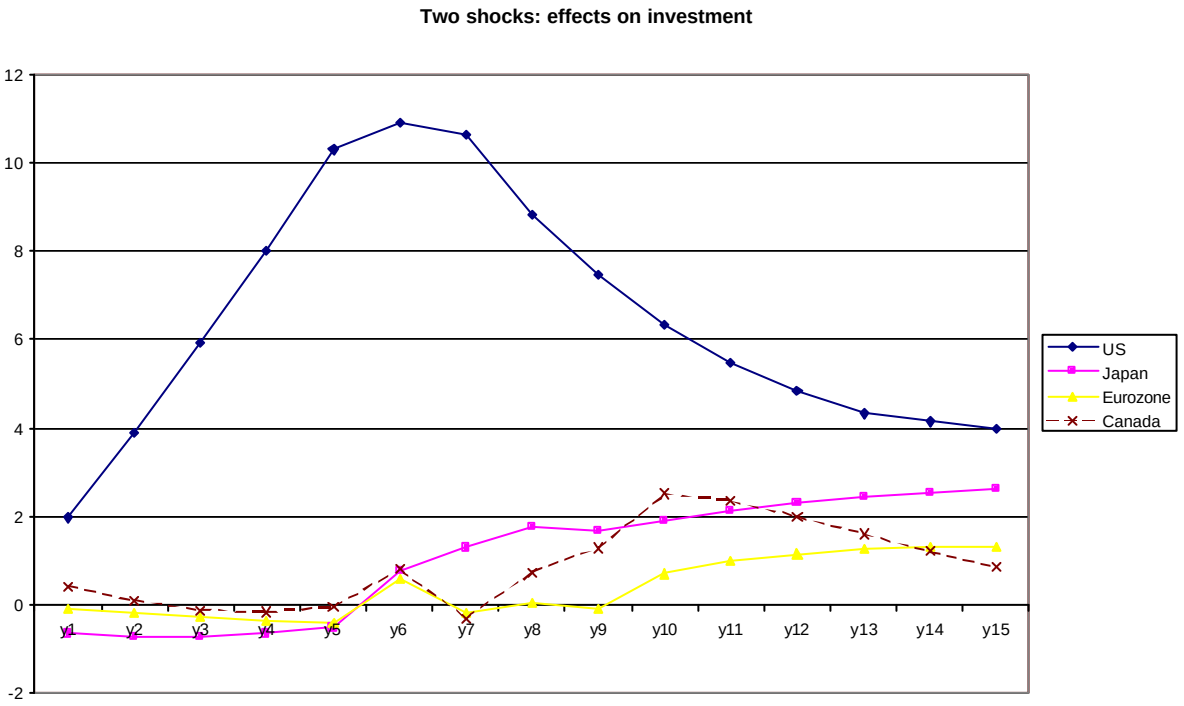



Chart 16: Combination of the two shocks, effects on investment (% deviation from baseline)

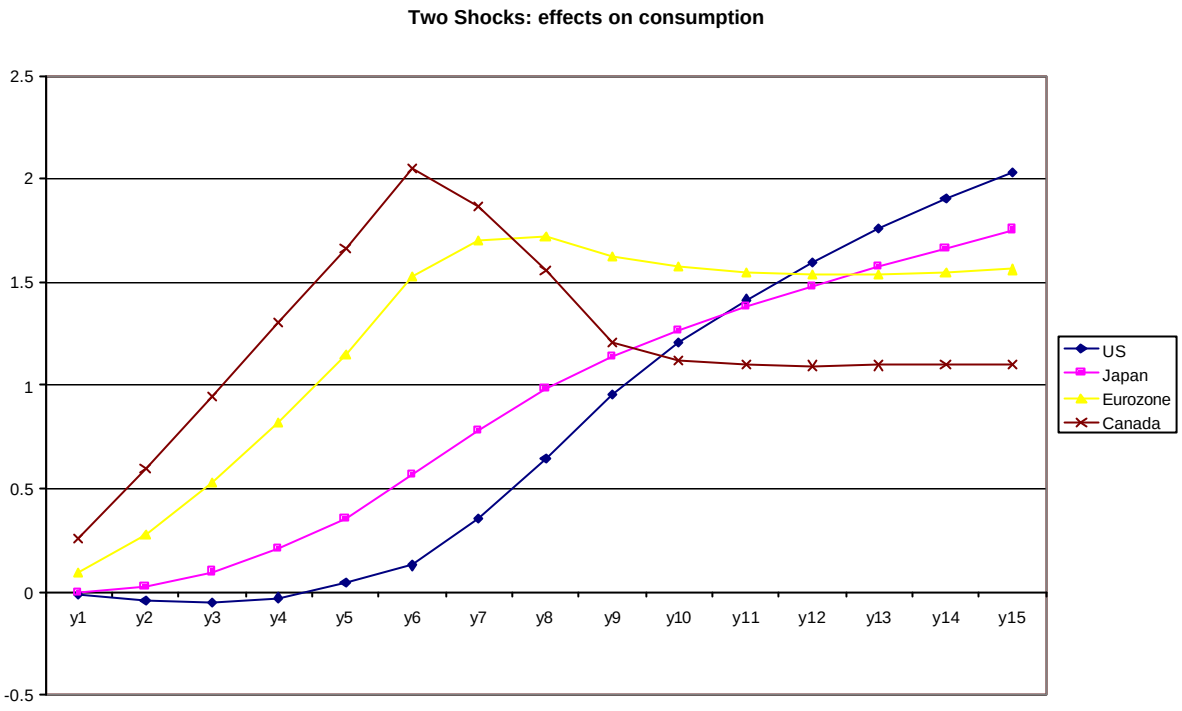
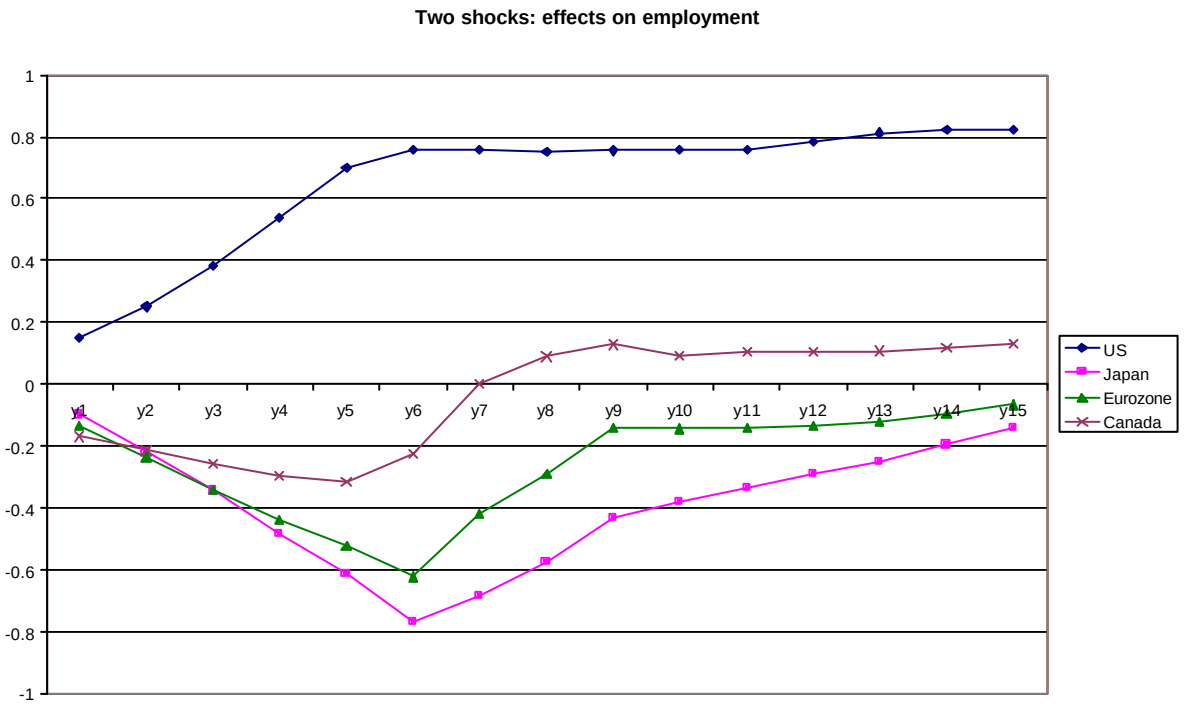



Chart 17: Combination of the two shocks, effects on consumption (% deviation from baseline)

Chart 18: Combination of the two shocks, effects on employment (% deviation from baseline)



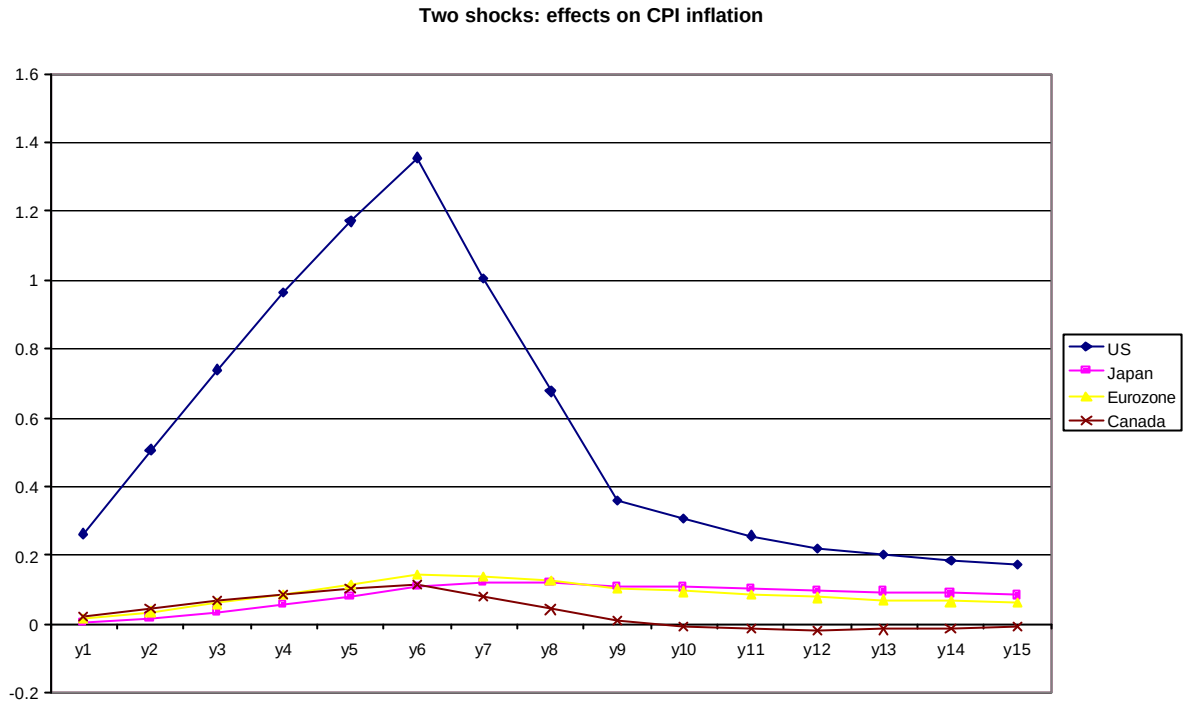



Chart 19: Combination of the two shocks, effects on CPI inflation (absolute deviation from baseline)

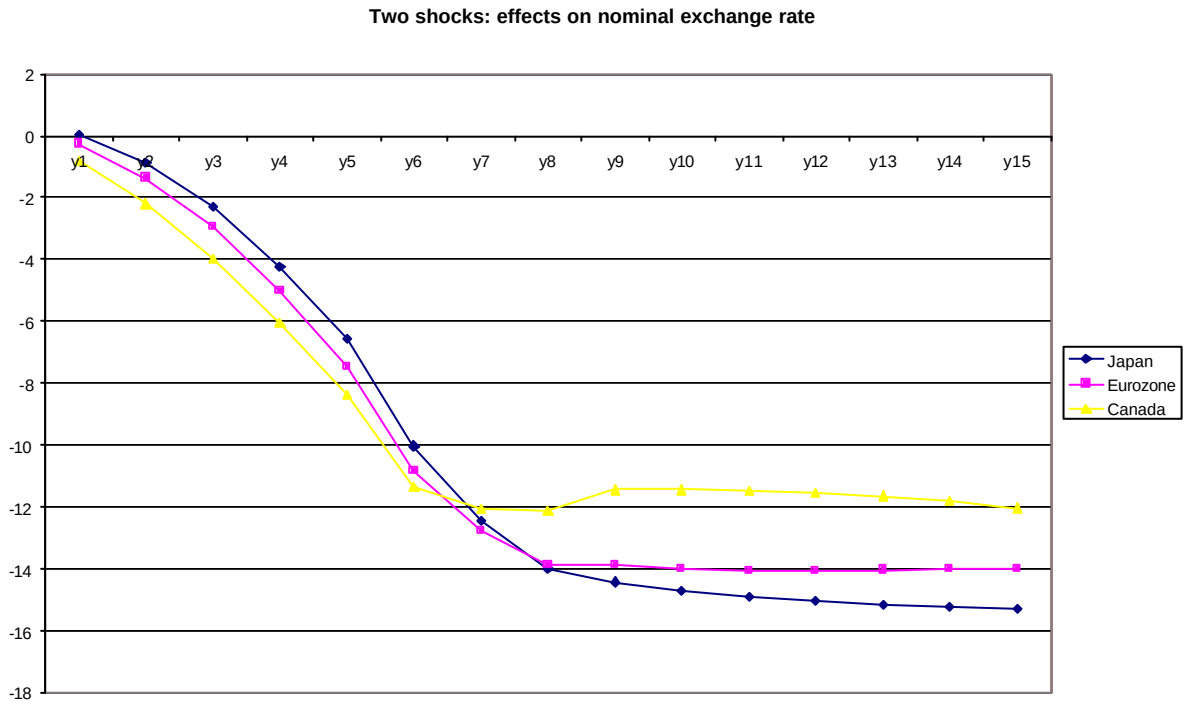



Chart 20: Combination of the two shocks, effects on nominal exchange rate vis-à-vis the US dollar (% deviation from baseline)

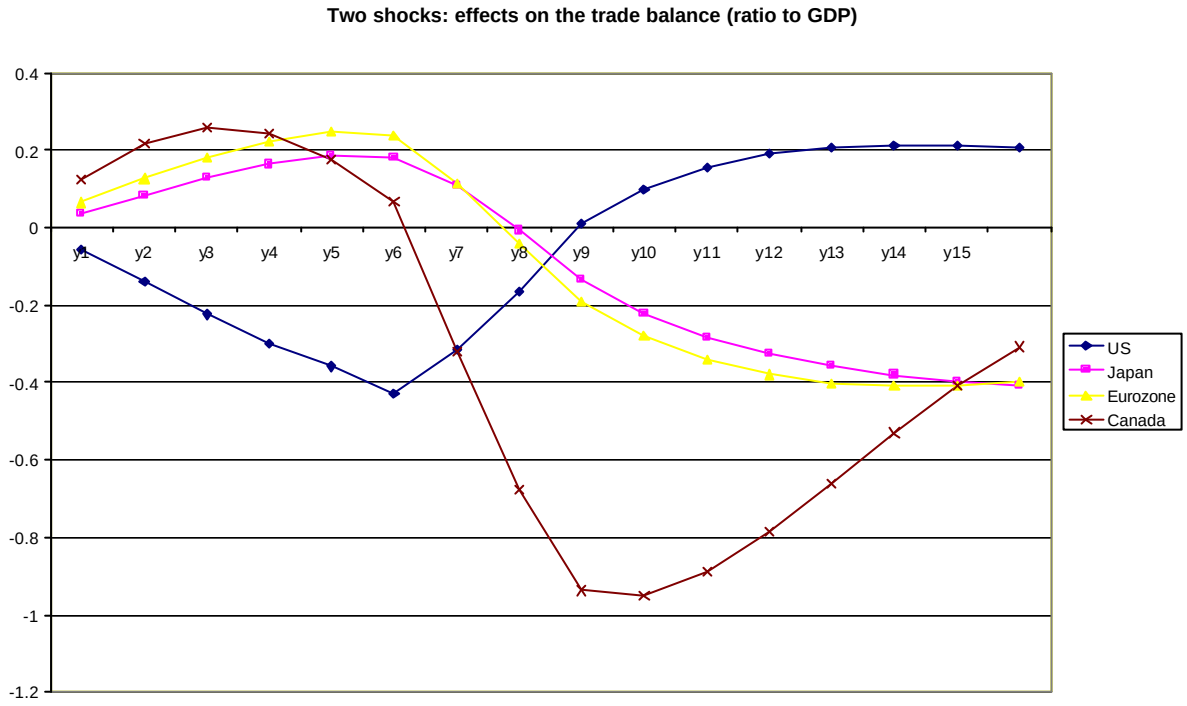



Chart 21: Combination of the two shocks, effects on trade balance to GDP ratio (absolute deviation from baseline)

Appendix A. An anticipated productivity shock in the US

We also computed a simulation where the global productivity of both factors embodied in new production units was permanently increased by 0.25% in the United States in year 1. This increase was assumed to have been perfectly anticipated by economic agents as soon as in year 0. The long run effects of this shock are of course the same as for the unanticipated shock commented in paragraphs 3.1 and 3.2. However, in the short run there are strong differences between both simulations.

The main difference in the US is that the expectation of an increase in the efficiency of capital starting in year 1 drives a strong decrease in investment in year 0. Part of this decrease is compensated by higher investment in year 1, but also, although to a lesser extent, in the following years.

In year 1 and afterward, effective demand is stronger than for the simulation commented in paragraph 3.1. So, inflation and the nominal and real interest rates are higher although they continue to decrease progressively to 0. This dynamic of the real interest rate explains that the part of the increase in investment, which compensate for the decrease in year 0, is allocated over several years instead of being concentrated on year 1.

We also simulated the effects of a permanent increase in the *growth rate* of the total productivity of factors, starting in year 0 and perfectly anticipated since this year. The relative change in investment, relatively to the baseline, was negative and decreasing for two years, then negative and increasing for several more years, then positive and increasing. The reason for the decrease in investment in the short run is that for their total lifetime these investments will be stuck in technologies less efficient than those which will be available a few years later. Models assuming putty-putty technology, with disembodied technical progress, cannot catch this mechanism: all capital immediately integrates technological improvements, so there is no reason to postpone investment when these improvements are assumed to take place in the future. We obtained the same temporary depression, followed by a steady expansion, for the other business indicators (potential output, GDP, employment, consumption, output deflator, interest rate, exchange rate, foreign indebtedness, exports, imports, the cost of labour, capital intensity). This evolution differs from what we observed in the 1990s.

These results explain why, in paragraph 3.3, we assumed that each year the increase in the growth rate of the total productivity of factors was expected to be short lived and that its continuation for 6 successive years was a succession of surprises. It could be more realistic to make the less extreme (but less clear-cut) assumption that the higher growth rate was expected to come back progressively to its former trend. There exists another interpretation, which we will not explore and which could be investigated with putty-putty models with embodied technical progress, which is that new technology also increased the efficiency of old production units. Under this assumption the case for postponing investment to years when better technology is available, disappears.

***Appendix B. The effects of a permanent unanticipated increase of productivity by 0.25% in the US***

| **USA** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 0.046 | 0.088 | 0.103 | 0.118 | 0.145 | 0.154 | 0.164 | 0.174 | 0.183 | 0.319 |
| Effective demand | 0.050 | 0.095 | 0.115 | 0.134 | 0.161 | 0.175 | 0.189 | 0.203 | 0.216 | 0.377 |
| Potential production | -0.010 | 0.009 | 0.031 | 0.053 | 0.082 | 0.101 | 0.121 | 0.140 | 0.158 | 0.377 |
| Consumption | -0.013 | -0.013 | -0.008 | 0.000 | 0.012 | 0.025 | 0.038 | 0.052 | 0.066 | 0.311 |
| Investment | 0.242 | 0.429 | 0.462 | 0.478 | 0.541 | 0.525 | 0.511 | 0.496 | 0.480 | 0.258 |
| Capital intensity | -0.120 | -0.101 | -0.083 | -0.066 | -0.051 | -0.037 | -0.023 | -0.011 | 0.000 | 0.143 |
| Age of the oldest capital units | -0.021 | -0.030 | -0.041 | -0.054 | -0.067 | -0.083 | -0.096 | -0.107 | -0.118 | -0.029 |
| Age of the new capital units | -0.085 | -0.075 | -0.071 | -0.068 | -0.065 | -0.065 | -0.063 | -0.061 | -0.059 | -0.029 |
| Employment | -0.017 | -0.012 | -0.005 | 0.001 | 0.007 | 0.009 | 0.013 | 0.018 | 0.022 | 0.070 |
| Real cost of labour | 0.031 | 0.048 | 0.065 | 0.082 | 0.100 | 0.121 | 0.138 | 0.153 | 0.167 | 0.339 |
| Production prices | 0.036 | 0.087 | 0.138 | 0.187 | 0.234 | 0.279 | 0.320 | 0.357 | 0.392 | 0.876 |
| Inflation | 0.036 | 0.051 | 0.050 | 0.049 | 0.048 | 0.044 | 0.041 | 0.038 | 0.035 | 0.000 |
| Consumption prices | 0.065 | 0.126 | 0.186 | 0.243 | 0.297 | 0.347 | 0.393 | 0.435 | 0.473 | 0.967 |
| Consumption inflation | 0.066 | 0.062 | 0.060 | 0.058 | 0.054 | 0.050 | 0.046 | 0.042 | 0.038 | 0.000 |
| Nominal exchange rate | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Real exchange rate | 0.156 | 0.207 | 0.254 | 0.297 | 0.331 | 0.361 | 0.386 | 0.407 | 0.425 | 0.485 |
| Short-term interest rate | 0.100 | 0.095 | 0.091 | 0.088 | 0.083 | 0.076 | 0.069 | 0.064 | 0.058 | 0.000 |
| Real interest rate | 0.047 | 0.043 | 0.041 | 0.039 | 0.038 | 0.034 | 0.031 | 0.028 | 0.026 | 0.000 |
| Trade balance/GDP | -0.013 | -0.013 | -0.012 | -0.010 | -0.008 | -0.006 | -0.003 | -0.001 | 0.001 | 0.012 |
| Exports | 0.051 | 0.093 | 0.130 | 0.161 | 0.187 | 0.208 | 0.224 | 0.238 | 0.248 | 0.362 |
| Imports | 0.023 | 0.035 | 0.041 | 0.042 | 0.045 | 0.043 | 0.039 | 0.033 | 0.027 | 0.043 |
| Export price | 0.111 | 0.213 | 0.310 | 0.403 | 0.489 | 0.566 | 0.636 | 0.698 | 0.754 | 1.278 |
| Import price | 0.218 | 0.332 | 0.439 | 0.539 | 0.627 | 0.707 | 0.778 | 0.841 | 0.897 | 1.447 |
| Public balance | -0.061 | -0.050 | -0.041 | -0.032 | -0.024 | -0.018 | -0.014 | -0.009 | -0.005 | 0.011 |
| Net foreign assets/GDP | 0.094 | 0.084 | 0.068 | 0.054 | 0.026 | 0.010 | -0.005 | -0.017 | -0.028 | -0.063 |
| Public debt/GDP | -0.220 | -0.187 | -0.154 | -0.131 | -0.098 | -0.096 | -0.099 | -0.106 | -0.115 | -0.687 |

In the tables of Appendices B. and C. all variables are expressed as percentage deviation from the baseline. except inflation and interest rates (absolute deviation). trade and public balance and net foreign assets and public debt (absolute deviation expressed in points of GDP).

| **Japan** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 0.010 | 0.018 | 0.023 | 0.028 | 0.031 | 0.036 | 0.040 | 0.044 | 0.048 | 0.179 |
| Effective demand | 0.011 | 0.016 | 0.018 | 0.020 | 0.020 | 0.022 | 0.024 | 0.027 | 0.029 | 0.155 |
| Potential production | -0.001 | -0.002 | -0.001 | 0.000 | 0.003 | 0.005 | 0.008 | 0.010 | 0.013 | 0.153 |
| Consumption | 0.005 | 0.012 | 0.021 | 0.031 | 0.041 | 0.051 | 0.061 | 0.070 | 0.079 | 0.294 |
| Investment | 0.025 | 0.041 | 0.054 | 0.069 | 0.080 | 0.093 | 0.106 | 0.119 | 0.131 | 0.307 |
| Capital intensity | 0.023 | 0.024 | 0.024 | 0.025 | 0.026 | 0.028 | 0.029 | 0.031 | 0.033 | 0.073 |
| Age of the oldest capital units | -0.002 | -0.006 | -0.007 | -0.006 | -0.005 | -0.004 | -0.004 | -0.004 | -0.004 | -0.017 |
| Age of the new capital units | -0.024 | -0.024 | -0.024 | -0.024 | -0.025 | -0.026 | -0.025 | -0.025 | -0.025 | -0.014 |
| Employment | -0.001 | -0.003 | -0.003 | -0.002 | 0.000 | 0.002 | 0.004 | 0.006 | 0.008 | 0.122 |
| Real cost of labour | 0.006 | 0.008 | 0.007 | 0.006 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.049 |
| Production prices | 0.007 | 0.018 | 0.029 | 0.041 | 0.052 | 0.062 | 0.072 | 0.082 | 0.091 | 0.106 |
| Inflation | 0.007 | 0.011 | 0.011 | 0.012 | 0.010 | 0.010 | 0.010 | 0.010 | 0.009 | 0.001 |
| Consumption prices | 0.002 | 0.006 | 0.010 | 0.014 | 0.018 | 0.023 | 0.028 | 0.033 | 0.039 | 0.017 |
| Consumption inflation | 0.002 | 0.003 | 0.004 | 0.004 | 0.004 | 0.005 | 0.005 | 0.005 | 0.005 | 0.001 |
| Nominal exchange rate | -0.147 | -0.271 | -0.390 | -0.503 | -0.601 | -0.690 | -0.769 | -0.839 | -0.902 | -1.563 |
| Real exchange rate | 0.005 | -0.016 | -0.039 | -0.061 | -0.078 | -0.094 | -0.109 | -0.123 | -0.135 | -0.259 |
| Short-term interest rate | 0.004 | 0.005 | 0.006 | 0.007 | 0.007 | 0.007 | 0.008 | 0.008 | 0.008 | 0.001 |
| Real interest rate | -0.007 | -0.007 | -0.006 | -0.004 | -0.004 | -0.003 | -0.002 | -0.002 | -0.001 | 0.001 |
| Trade balance/GDP | 0.003 | 0.005 | 0.004 | 0.002 | 0.000 | -0.003 | -0.006 | -0.009 | -0.011 | -0.039 |
| Exports | 0.013 | 0.019 | 0.009 | -0.008 | -0.023 | -0.037 | -0.050 | -0.062 | -0.073 | -0.079 |
| Imports | 0.004 | 0.009 | 0.018 | 0.031 | 0.045 | 0.059 | 0.074 | 0.089 | 0.103 | 0.353 |
| Export price | 0.030 | 0.032 | 0.033 | 0.032 | 0.031 | 0.029 | 0.027 | 0.025 | 0.023 | -0.096 |
| Import price | 0.007 | -0.007 | -0.023 | -0.040 | -0.050 | -0.061 | -0.070 | -0.079 | -0.087 | -0.245 |
| Public balance | -0.009 | -0.008 | -0.008 | -0.008 | -0.004 | -0.003 | -0.003 | -0.002 | -0.002 | 0.014 |
| Net foreign assets/GDP | -0.125 | -0.137 | -0.148 | -0.160 | -0.139 | -0.137 | -0.133 | -0.127 | -0.122 | -0.074 |
| Public debt/GDP | -0.046 | -0.049 | -0.050 | -0.056 | -0.035 | -0.043 | -0.051 | -0.059 | -0.067 | -0.424 |

| **Euro zone** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 0.042 | 0.026 | 0.029 | 0.032 | 0.034 | 0.036 | 0.038 | 0.040 | 0.042 | 0.090 |
| Effective demand | 0.041 | 0.019 | 0.019 | 0.019 | 0.019 | 0.019 | 0.018 | 0.018 | 0.018 | 0.067 |
| Potential production | -0.003 | 0.004 | 0.004 | 0.004 | 0.005 | 0.006 | 0.006 | 0.007 | 0.008 | 0.068 |
| Consumption | 0.030 | 0.051 | 0.065 | 0.076 | 0.084 | 0.091 | 0.096 | 0.101 | 0.104 | 0.180 |
| Investment | 0.138 | 0.019 | 0.010 | 0.012 | 0.012 | 0.018 | 0.026 | 0.035 | 0.043 | 0.091 |
| Capital intensity | 0.001 | 0.001 | 0.002 | 0.002 | 0.003 | 0.004 | 0.005 | 0.006 | 0.007 | 0.038 |
| Age of the oldest capital units | -0.009 | -0.002 | -0.004 | -0.004 | -0.003 | -0.002 | -0.001 | -0.001 | 0.000 | -0.007 |
| Age of the new capital units | -0.012 | -0.012 | -0.012 | -0.011 | -0.011 | -0.010 | -0.010 | -0.010 | -0.010 | -0.007 |
| Employment | -0.005 | 0.003 | 0.002 | 0.003 | 0.004 | 0.004 | 0.005 | 0.006 | 0.006 | 0.056 |
| Real cost of labour | -0.001 | 0.004 | 0.005 | 0.004 | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.020 |
| Production prices | 0.027 | 0.035 | 0.044 | 0.053 | 0.061 | 0.069 | 0.076 | 0.083 | 0.089 | 0.251 |
| Inflation | 0.027 | 0.009 | 0.009 | 0.009 | 0.008 | 0.008 | 0.007 | 0.007 | 0.006 | -0.001 |
| Consumption prices | 0.004 | 0.008 | 0.013 | 0.018 | 0.023 | 0.029 | 0.034 | 0.040 | 0.045 | 0.206 |
| Consumption inflation | 0.004 | 0.004 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.000 |
| Nominal exchange rate | -0.193 | -0.310 | -0.419 | -0.521 | -0.610 | -0.690 | -0.760 | -0.820 | -0.873 | -1.246 |
| Real exchange rate | -0.055 | -0.066 | -0.075 | -0.083 | -0.090 | -0.095 | -0.098 | -0.101 | -0.102 | -0.108 |
| Short-term interest rate | 0.006 | 0.007 | 0.007 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.008 | 0.000 |
| Real interest rate | -0.003 | -0.003 | -0.002 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.002 | 0.000 |
| Trade balance/GDP | 0.008 | 0.007 | 0.004 | 0.002 | -0.001 | -0.004 | -0.007 | -0.010 | -0.012 | -0.021 |
| Exports | 0.004 | -0.004 | -0.011 | -0.018 | -0.020 | -0.025 | -0.030 | -0.035 | -0.040 | 0.007 |
| Imports | 0.018 | 0.030 | 0.042 | 0.052 | 0.062 | 0.071 | 0.080 | 0.087 | 0.094 | 0.180 |
| Export price | 0.019 | 0.020 | 0.021 | 0.022 | 0.023 | 0.024 | 0.026 | 0.028 | 0.031 | 0.182 |
| Import price | -0.070 | -0.071 | -0.072 | -0.072 | -0.068 | -0.064 | -0.059 | -0.052 | -0.045 | 0.124 |
| Public balance | -0.005 | 0.000 | 0.001 | 0.002 | 0.006 | 0.007 | 0.007 | 0.008 | 0.008 | 0.013 |
| Net foreign assets/GDP | -0.108 | -0.105 | -0.106 | -0.107 | -0.090 | -0.083 | -0.076 | -0.069 | -0.063 | -0.056 |
| Public debt/GDP | -0.068 | -0.057 | -0.062 | -0.067 | -0.061 | -0.070 | -0.078 | -0.086 | -0.094 | -0.389 |

| **Canada** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 0.067 | 0.013 | 0.015 | 0.019 | 0.026 | 0.032 | 0.036 | 0.040 | 0.043 | 0.054 |
| Effective demand | 0.081 | 0.013 | 0.008 | 0.006 | 0.006 | 0.006 | 0.008 | 0.009 | 0.012 | 0.039 |
| Potential production | 0.000 | 0.011 | 0.008 | 0.007 | 0.008 | 0.009 | 0.011 | 0.012 | 0.014 | 0.039 |
| Consumption | 0.070 | 0.085 | 0.087 | 0.088 | 0.087 | 0.087 | 0.087 | 0.087 | 0.087 | 0.130 |
| Investment | 0.203 | -0.035 | -0.002 | 0.034 | 0.061 | 0.078 | 0.086 | 0.089 | 0.088 | 0.037 |
| Capital intensity | 0.004 | 0.005 | 0.007 | 0.008 | 0.010 | 0.011 | 0.012 | 0.012 | 0.013 | 0.025 |
| Age of the oldest capital units | 0.000 | 0.007 | 0.004 | 0.004 | 0.004 | 0.003 | 0.002 | 0.001 | -0.001 | -0.004 |
| Age of the new capital units | -0.006 | -0.007 | -0.006 | -0.005 | -0.004 | -0.003 | -0.002 | -0.002 | -0.002 | -0.005 |
| Employment | 0.000 | 0.011 | 0.008 | 0.007 | 0.008 | 0.008 | 0.009 | 0.009 | 0.010 | 0.032 |
| Real cost of labour | -0.014 | -0.006 | -0.004 | -0.004 | -0.004 | -0.003 | -0.002 | 0.000 | 0.002 | 0.012 |
| Production prices | 0.049 | 0.050 | 0.050 | 0.049 | 0.048 | 0.046 | 0.044 | 0.043 | 0.041 | 0.145 |
| Inflation | 0.049 | 0.001 | 0.000 | -0.001 | -0.001 | -0.002 | -0.002 | -0.002 | -0.001 | 0.000 |
| Consumption prices | 0.004 | 0.008 | 0.012 | 0.015 | 0.017 | 0.019 | 0.020 | 0.021 | 0.022 | 0.116 |
| Consumption inflation | 0.004 | 0.004 | 0.003 | 0.003 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0.000 |
| Nominal exchange rate | -0.270 | -0.355 | -0.430 | -0.500 | -0.563 | -0.620 | -0.671 | -0.717 | -0.760 | -1.207 |
| Real exchange rate | -0.150 | -0.133 | -0.112 | -0.090 | -0.069 | -0.050 | -0.032 | -0.017 | -0.005 | -0.029 |
| Short-term interest rate | 0.007 | 0.006 | 0.005 | 0.005 | 0.004 | 0.003 | 0.002 | 0.001 | 0.001 | 0.000 |
| Real interest rate | 0.005 | 0.006 | 0.006 | 0.006 | 0.005 | 0.005 | 0.004 | 0.003 | 0.002 | 0.000 |
| Trade balance/GDP | 0.020 | 0.007 | -0.008 | -0.020 | -0.027 | -0.032 | -0.036 | -0.037 | -0.037 | -0.019 |
| Exports | -0.012 | -0.013 | -0.008 | -0.003 | 0.009 | 0.018 | 0.025 | 0.031 | 0.035 | 0.051 |
| Imports | 0.025 | 0.046 | 0.062 | 0.075 | 0.083 | 0.088 | 0.090 | 0.089 | 0.087 | 0.103 |
| Export price | 0.006 | 0.014 | 0.024 | 0.036 | 0.047 | 0.058 | 0.069 | 0.079 | 0.088 | 0.205 |
| Import price | -0.157 | -0.132 | -0.104 | -0.076 | -0.050 | -0.028 | -0.008 | 0.009 | 0.022 | 0.083 |
| Public balance | -0.006 | 0.006 | 0.007 | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.006 |
| Net foreign assets/GDP | 0.058 | 0.080 | 0.091 | 0.090 | 0.080 | 0.075 | 0.064 | 0.050 | 0.035 | -0.056 |
| Public debt/GDP | -0.098 | -0.050 | -0.050 | -0.052 | -0.051 | -0.058 | -0.066 | -0.074 | -0.082 | -0.251 |

## *Appendix C. The effects of a permanent unanticipated increase in the riskiness of Canada. Europe and Japan*

**USA**

| **years** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | 0.136 | 0.007 | 0.005 | 0.008 | 0.016 | 0.020 | 0.024 | 0.026 | 0.027 | -0.019 |
| Effective demand | 0.111 | 0.000 | 0.002 | 0.006 | 0.015 | 0.020 | 0.024 | 0.027 | 0.029 | -0.020 |
| Potential production | 0.009 | 0.036 | 0.039 | 0.041 | 0.048 | 0.047 | 0.047 | 0.047 | 0.046 | -0.019 |
| Consumption | 0.017 | 0.023 | 0.024 | 0.024 | 0.023 | 0.022 | 0.020 | 0.018 | 0.016 | -0.052 |
| Investment | 0.784 | 0.216 | 0.211 | 0.187 | 0.162 | 0.123 | 0.087 | 0.058 | 0.033 | -0.029 |
| Capital intensity | 0.017 | 0.021 | 0.023 | 0.024 | 0.024 | 0.024 | 0.023 | 0.021 | 0.020 | -0.011 |
| Age of the oldest capital units | 0.019 | 0.021 | 0.012 | 0.007 | 0.000 | -0.007 | -0.011 | -0.013 | -0.014 | 0.002 |
| Age of the new capital units | 0.008 | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.009 | 0.008 | 0.002 |
| Employment | 0.015 | 0.039 | 0.038 | 0.038 | 0.038 | 0.035 | 0.033 | 0.033 | 0.032 | -0.016 |
| Real cost of labour | -0.035 | -0.024 | -0.012 | -0.006 | 0.002 | 0.011 | 0.015 | 0.018 | 0.019 | -0.006 |
| Production prices | 0.061 | 0.039 | 0.017 | -0.004 | -0.024 | -0.040 | -0.054 | -0.066 | -0.076 | -0.223 |
| Inflation | 0.061 | -0.022 | -0.022 | -0.021 | -0.020 | -0.017 | -0.014 | -0.012 | -0.010 | 0.000 |
| Consumption prices | 0.002 | 0.001 | -0.003 | -0.010 | -0.018 | -0.027 | -0.036 | -0.046 | -0.054 | -0.210 |
| Consumption inflation | 0.002 | -0.001 | -0.004 | -0.007 | -0.008 | -0.009 | -0.009 | -0.009 | -0.009 | 0.000 |
| Nominal exchange rate | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Real exchange rate | -0.314 | -0.200 | -0.104 | -0.027 | 0.033 | 0.073 | 0.097 | 0.109 | 0.114 | 0.066 |
| Short-term interest rate | 0.003 | -0.002 | -0.006 | -0.010 | -0.013 | -0.014 | -0.014 | -0.014 | -0.014 | 0.000 |
| Real interest rate | 0.026 | 0.020 | 0.015 | 0.010 | 0.004 | 0.000 | -0.002 | -0.004 | -0.005 | 0.000 |
| Trade balance/GDP | 0.012 | -0.017 | -0.031 | -0.037 | -0.035 | -0.029 | -0.023 | -0.016 | -0.009 | 0.010 |
| Exports | -0.140 | -0.187 | -0.168 | -0.122 | -0.070 | -0.021 | 0.019 | 0.050 | 0.072 | 0.048 |
| Imports | 0.073 | 0.116 | 0.129 | 0.123 | 0.107 | 0.084 | 0.061 | 0.039 | 0.019 | -0.061 |
| Export price | -0.071 | -0.072 | -0.069 | -0.064 | -0.057 | -0.052 | -0.047 | -0.043 | -0.041 | -0.168 |
| Import price | -0.308 | -0.200 | -0.111 | -0.041 | 0.010 | 0.040 | 0.056 | 0.061 | 0.058 | -0.144 |
| Public balance | 0.009 | 0.013 | 0.013 | 0.012 | 0.011 | 0.010 | 0.010 | 0.009 | 0.008 | -0.001 |
| Net foreign assets/GDP | 0.023 | 0.002 | -0.019 | -0.052 | -0.082 | -0.121 | -0.154 | -0.183 | -0.205 | -0.268 |
| Public debt/GDP | -0.057 | 0.000 | -0.002 | -0.006 | -0.017 | -0.022 | -0.028 | -0.034 | -0.040 | 0.065 |

**Japan**

| **years** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | -0.109 | -0.021 | -0.019 | -0.019 | -0.023 | -0.025 | -0.027 | -0.029 | -0.029 | 0.051 |
| Effective demand | -0.095 | -0.005 | -0.009 | -0.013 | -0.020 | -0.024 | -0.028 | -0.031 | -0.033 | 0.050 |
| Potential production | 0.002 | -0.025 | -0.028 | -0.033 | -0.041 | -0.044 | -0.047 | -0.049 | -0.051 | 0.048 |
| Consumption | -0.011 | -0.015 | -0.014 | -0.014 | -0.014 | -0.014 | -0.013 | -0.013 | -0.013 | 0.079 |
| Investment | -0.543 | -0.214 | -0.225 | -0.220 | -0.210 | -0.187 | -0.162 | -0.138 | -0.115 | 0.141 |
| Capital intensity | -0.027 | -0.029 | -0.030 | -0.031 | -0.031 | -0.031 | -0.031 | -0.030 | -0.029 | 0.015 |
| Age of the oldest capital units | 0.005 | -0.020 | -0.012 | -0.007 | -0.004 | 0.003 | 0.007 | 0.009 | 0.011 | -0.008 |
| Age of the new capital units | -0.010 | -0.010 | -0.011 | -0.011 | -0.012 | -0.012 | -0.012 | -0.012 | -0.012 | -0.003 |
| Employment | 0.003 | -0.026 | -0.026 | -0.029 | -0.032 | -0.033 | -0.035 | -0.036 | -0.038 | 0.037 |
| Real cost of labour | 0.026 | 0.015 | 0.008 | 0.004 | -0.001 | -0.007 | -0.011 | -0.014 | -0.016 | 0.017 |
| Production prices | -0.058 | -0.046 | -0.034 | -0.022 | -0.010 | 0.002 | 0.013 | 0.024 | 0.035 | 0.158 |
| Inflation | -0.058 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.011 | 0.011 | 0.011 | 0.001 |
| Consumption prices | -0.002 | -0.003 | -0.003 | -0.001 | 0.003 | 0.008 | 0.014 | 0.020 | 0.027 | 0.139 |
| Consumption inflation | -0.002 | -0.001 | 0.000 | 0.002 | 0.004 | 0.005 | 0.006 | 0.006 | 0.007 | 0.001 |
| Nominal exchange rate | 0.349 | 0.266 | 0.193 | 0.132 | 0.084 | 0.050 | 0.026 | 0.012 | 0.005 | 0.234 |
| Real exchange rate | 0.188 | 0.149 | 0.112 | 0.081 | 0.052 | 0.029 | 0.009 | -0.008 | -0.022 | -0.066 |
| Short-term interest rate | -0.004 | -0.002 | 0.001 | 0.003 | 0.006 | 0.008 | 0.009 | 0.010 | 0.011 | 0.001 |
| Real interest rate | -0.016 | -0.013 | -0.011 | -0.010 | -0.006 | -0.004 | -0.002 | -0.001 | 0.000 | 0.001 |
| Trade balance/GDP | 0.005 | 0.018 | 0.026 | 0.028 | 0.027 | 0.023 | 0.019 | 0.014 | 0.010 | -0.019 |
| Exports | 0.083 | 0.155 | 0.163 | 0.142 | 0.107 | 0.069 | 0.033 | 0.002 | -0.024 | -0.072 |
| Imports | -0.058 | -0.089 | -0.105 | -0.111 | -0.109 | -0.103 | -0.093 | -0.082 | -0.069 | 0.098 |
| Export price | 0.000 | 0.021 | 0.037 | 0.048 | 0.057 | 0.062 | 0.064 | 0.064 | 0.064 | 0.104 |
| Import price | 0.171 | 0.131 | 0.099 | 0.073 | 0.052 | 0.037 | 0.026 | 0.018 | 0.012 | 0.072 |
| Public balance | -0.003 | -0.012 | -0.012 | -0.013 | -0.013 | -0.014 | -0.015 | -0.016 | -0.016 | 0.003 |
| Net foreign assets/GDP | 0.130 | 0.091 | 0.084 | 0.086 | 0.084 | 0.094 | 0.107 | 0.120 | 0.133 | 0.212 |
| Public debt/GDP | 0.121 | 0.015 | 0.022 | 0.025 | 0.056 | 0.058 | 0.061 | 0.065 | 0.068 | -0.124 |

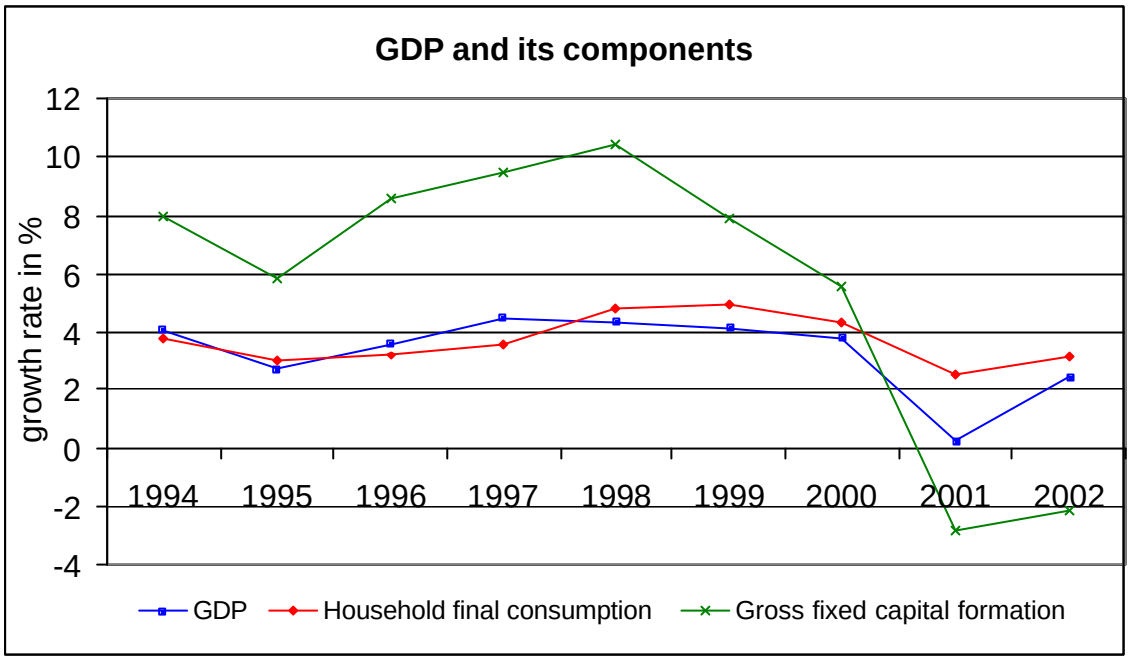
**Euro zone**

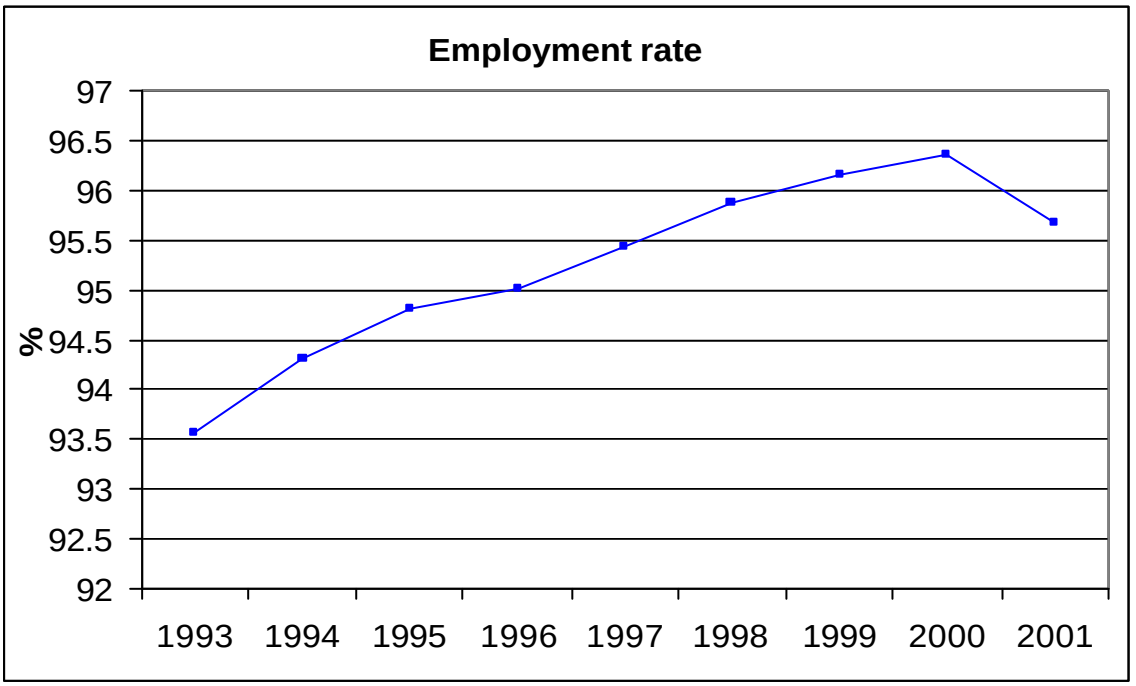
| **years** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | -0.082 | 0.001 | -0.002 | -0.005 | -0.012 | -0.014 | -0.017 | -0.018 | -0.018 | 0.011 |
| Effective demand | -0.077 | 0.013 | 0.007 | 0.001 | -0.009 | -0.014 | -0.019 | -0.022 | -0.024 | 0.008 |
| Potential production | 0.001 | -0.026 | -0.026 | -0.028 | -0.034 | -0.033 | -0.034 | -0.034 | -0.034 | 0.008 |
| Consumption | -0.013 | -0.016 | -0.015 | -0.013 | -0.012 | -0.010 | -0.008 | -0.006 | -0.004 | 0.036 |
| Investment | -0.509 | -0.135 | -0.149 | -0.144 | -0.133 | -0.104 | -0.079 | -0.057 | -0.037 | 0.016 |
| Capital intensity | -0.018 | -0.020 | -0.021 | -0.022 | -0.022 | -0.021 | -0.020 | -0.019 | -0.018 | 0.003 |
| Age of the oldest capital units | 0.005 | -0.027 | -0.018 | -0.012 | -0.005 | 0.007 | 0.010 | 0.012 | 0.013 | -0.002 |
| Age of the new capital units | -0.004 | -0.004 | -0.004 | -0.004 | -0.004 | -0.004 | -0.004 | -0.004 | -0.004 | -0.001 |
| Employment | 0.002 | -0.030 | -0.028 | -0.028 | -0.028 | -0.024 | -0.024 | -0.024 | -0.024 | 0.007 |
| Real cost of labour | 0.031 | 0.019 | 0.012 | 0.007 | -0.001 | -0.009 | -0.012 | -0.014 | -0.015 | 0.003 |
| Production prices | -0.047 | -0.024 | -0.004 | 0.014 | 0.029 | 0.041 | 0.050 | 0.057 | 0.063 | 0.141 |
| Inflation | -0.047 | 0.023 | 0.020 | 0.017 | 0.015 | 0.012 | 0.009 | 0.007 | 0.006 | 0.000 |
| Consumption prices | 0.000 | 0.001 | 0.005 | 0.009 | 0.016 | 0.022 | 0.028 | 0.035 | 0.041 | 0.137 |
| Consumption inflation | 0.000 | 0.002 | 0.003 | 0.005 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.000 |
| Nominal exchange rate | 0.301 | 0.213 | 0.138 | 0.080 | 0.034 | 0.006 | -0.010 | -0.016 | -0.015 | 0.287 |
| Real exchange rate | 0.121 | 0.074 | 0.035 | 0.003 | -0.022 | -0.038 | -0.049 | -0.055 | -0.057 | -0.005 |
| Short-term interest rate | -0.001 | 0.002 | 0.005 | 0.007 | 0.009 | 0.010 | 0.010 | 0.010 | 0.009 | 0.000 |
| Real interest rate | -0.025 | -0.018 | -0.013 | -0.008 | -0.003 | 0.000 | 0.002 | 0.004 | 0.004 | 0.000 |
| Trade balance/GDP | 0.008 | 0.024 | 0.035 | 0.038 | 0.035 | 0.029 | 0.021 | 0.014 | 0.008 | -0.012 |
| Exports | 0.091 | 0.123 | 0.117 | 0.092 | 0.059 | 0.028 | 0.000 | -0.021 | -0.038 | -0.042 |
| Imports | -0.049 | -0.064 | -0.068 | -0.065 | -0.057 | -0.046 | -0.034 | -0.023 | -0.012 | 0.019 |
| Export price | -0.013 | 0.007 | 0.022 | 0.034 | 0.041 | 0.046 | 0.048 | 0.049 | 0.049 | 0.137 |
| Import price | 0.144 | 0.065 | 0.009 | -0.028 | -0.050 | -0.057 | -0.055 | -0.047 | -0.037 | 0.136 |
| Public balance | -0.002 | -0.013 | -0.012 | -0.012 | -0.012 | -0.011 | -0.011 | -0.010 | -0.009 | 0.002 |
| Net foreign assets/GDP | 0.082 | 0.052 | 0.055 | 0.070 | 0.084 | 0.110 | 0.136 | 0.159 | 0.179 | 0.224 |
| Public debt/GDP | 0.044 | -0.019 | -0.015 | -0.010 | 0.006 | 0.013 | 0.021 | 0.029 | 0.035 | -0.053 |

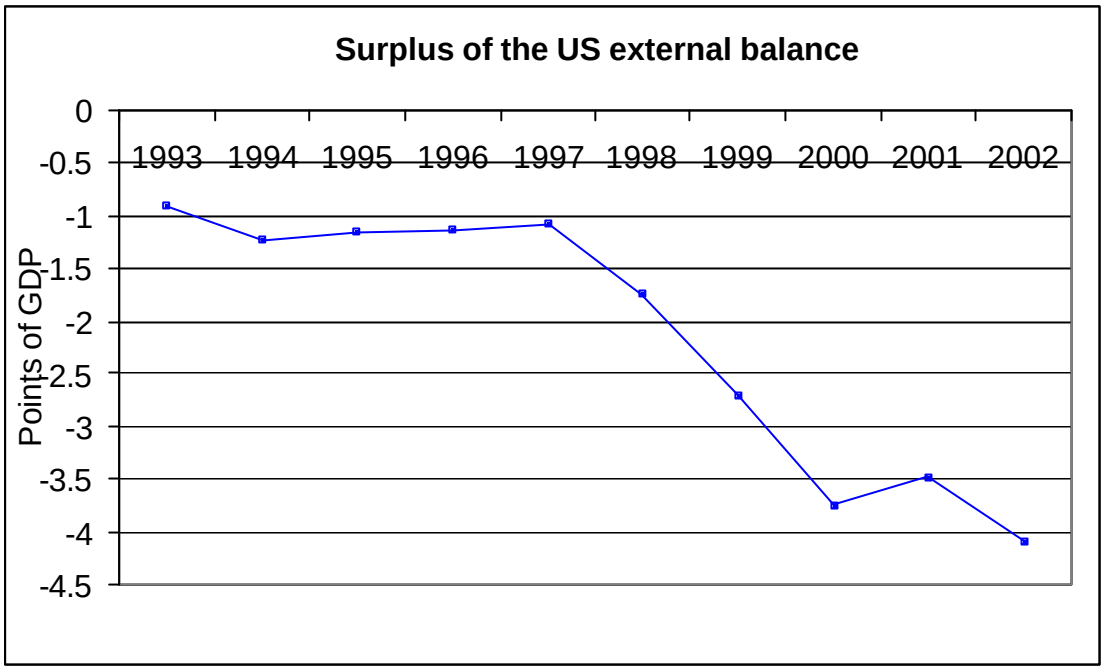
**Canada**

| **years** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **99** |
|---|---|---|---|---|---|---|---|---|---|---|
| GDP | -0.036 | 0.026 | 0.006 | -0.011 | -0.026 | -0.032 | -0.034 | -0.032 | -0.027 | -0.003 |
| Effective demand | -0.058 | 0.031 | 0.024 | 0.014 | 0.003 | -0.008 | -0.017 | -0.023 | -0.026 | -0.002 |
| Potential production | -0.009 | -0.024 | -0.021 | -0.022 | -0.023 | -0.023 | -0.023 | -0.023 | -0.022 | -0.002 |
| Consumption | -0.013 | -0.009 | -0.002 | 0.004 | 0.008 | 0.012 | 0.013 | 0.014 | 0.015 | 0.014 |
| Investment | -0.299 | -0.093 | -0.183 | -0.208 | -0.179 | -0.126 | -0.065 | -0.009 | 0.036 | -0.002 |
| Capital intensity | -0.015 | -0.017 | -0.018 | -0.017 | -0.016 | -0.014 | -0.012 | -0.010 | -0.008 | -0.002 |
| Age of the oldest capital units | -0.015 | -0.025 | -0.016 | -0.007 | 0.002 | 0.011 | 0.016 | 0.018 | 0.018 | 0.000 |
| Age of the new capital units | -0.003 | -0.003 | -0.003 | -0.003 | -0.003 | -0.002 | -0.002 | -0.001 | -0.001 | 0.000 |
| Employment | -0.013 | -0.029 | -0.022 | -0.019 | -0.016 | -0.013 | -0.012 | -0.011 | -0.010 | -0.002 |
| Real cost of labour | 0.033 | 0.023 | 0.011 | 0.002 | -0.007 | -0.015 | -0.020 | -0.023 | -0.023 | 0.000 |
| Production prices | -0.030 | 0.004 | 0.031 | 0.052 | 0.068 | 0.077 | 0.080 | 0.080 | 0.077 | 0.053 |
| Inflation | -0.030 | 0.033 | 0.027 | 0.022 | 0.016 | 0.009 | 0.003 | 0.000 | -0.003 | 0.000 |
| Consumption prices | 0.002 | 0.007 | 0.013 | 0.021 | 0.029 | 0.036 | 0.042 | 0.048 | 0.052 | 0.056 |
| Consumption inflation | 0.002 | 0.005 | 0.006 | 0.008 | 0.008 | 0.007 | 0.006 | 0.005 | 0.004 | 0.000 |
| Nominal exchange rate | 0.201 | 0.094 | 0.013 | -0.042 | -0.073 | -0.079 | -0.067 | -0.045 | -0.016 | 0.244 |
| Real exchange rate | 0.084 | -0.011 | -0.081 | -0.126 | -0.150 | -0.153 | -0.140 | -0.118 | -0.091 | 0.025 |
| Short-term interest rate | 0.004 | 0.007 | 0.010 | 0.011 | 0.012 | 0.011 | 0.010 | 0.008 | 0.006 | 0.000 |
| Real interest rate | -0.030 | -0.021 | -0.012 | -0.004 | 0.003 | 0.008 | 0.010 | 0.011 | 0.010 | 0.000 |
| Trade balance/GDP | -0.001 | 0.044 | 0.068 | 0.073 | 0.061 | 0.041 | 0.019 | -0.001 | -0.017 | -0.010 |
| Exports | 0.061 | 0.087 | 0.076 | 0.049 | 0.019 | -0.008 | -0.027 | -0.039 | -0.043 | -0.040 |
| Imports | -0.026 | -0.035 | -0.035 | -0.027 | -0.013 | 0.004 | 0.021 | 0.035 | 0.045 | -0.016 |
| Export price | -0.070 | -0.049 | -0.032 | -0.017 | -0.003 | 0.009 | 0.021 | 0.031 | 0.041 | 0.087 |
| Import price | 0.098 | -0.007 | -0.079 | -0.121 | -0.137 | -0.129 | -0.106 | -0.075 | -0.040 | 0.078 |
| Public balance | 0.002 | -0.013 | -0.013 | -0.013 | -0.007 | -0.005 | -0.004 | -0.002 | -0.001 | 0.000 |
| Net foreign assets/GDP | -0.021 | -0.022 | 0.018 | 0.082 | 0.148 | 0.220 | 0.276 | 0.313 | 0.331 | 0.225 |
| Public debt/GDP | 0.041 | -0.036 | -0.036 | -0.028 | -0.008 | 0.003 | 0.013 | 0.023 | 0.029 | -0.008 |

*Appendix D. Stylised facts in the US between 1993 and 2002*




Surplus of the US external balance
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
Points of GDP
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002