EUROPEAN CENTRAL BANK

WORKING PAPER SERIES

WORKING PAPER NO. 237

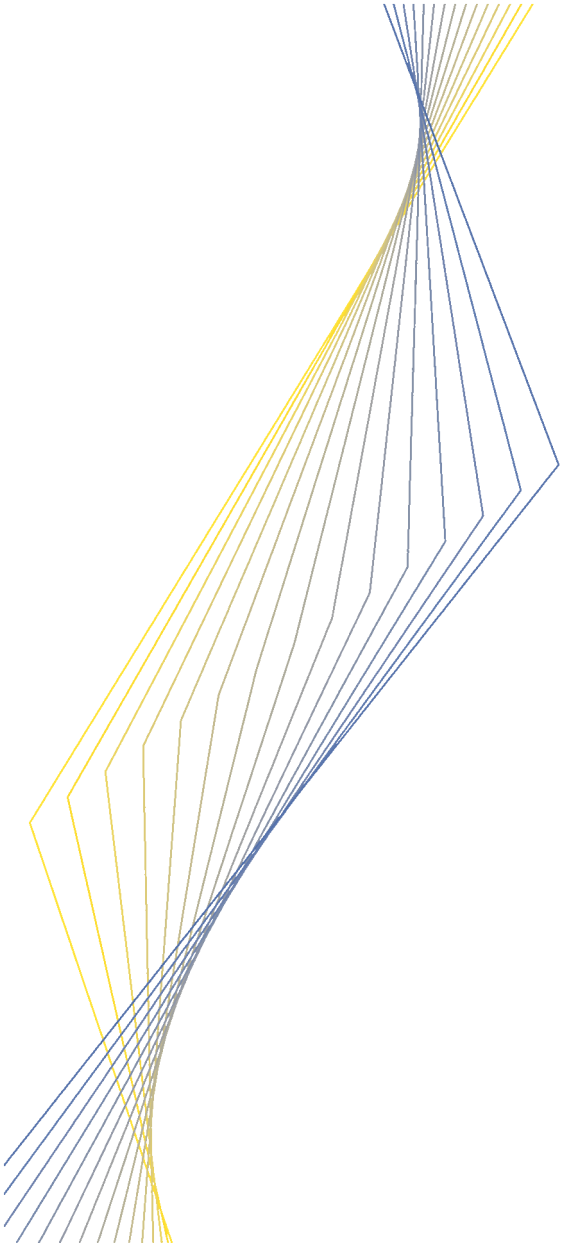
GROWTH EXPECTATIONS, CAPITAL FLOWS AND INTERNATIONAL RISK SHARING

BY OLLI CASTRÉN,
MARCUS MILLER
AND ROGER STIEGERT

June 2003

EUROPEAN CENTRAL BANK

WORKING PAPER SERIES



WORKING PAPER NO. 237

GROWTH EXPECTATIONS, CAPITAL FLOWS AND INTERNATIONAL RISK SHARING[1]

BY OLLI CASTRÉN[2], MARCUS MILLER[3] AND ROGER STIEGERT[2]

June 2003

1 This paper has benefited from comments and suggestions from Sayantan Ghosal, Stelios Makrydakis, Filippo di Mauro, Francesco Mongelli and Neil Rankin and participants at internal ECB seminars. We are grateful to Pongsak Luangaram for research assistance. The opinions expressed herein are those of the author(s) and do not necessarily represent those of the European Central Bank. or the European System of Central Banks. This paper can be downloaded without charge from http://www.ecb. int or from the Social Science Research Network electronic library at: http://ssrn.com/abstract_id=xxxxxx

2 European Central Bank, Kaiserstrasse 29, D-60311 Frankfurt am Main, Germany. E-mails: olli.castren@ecb.int, roger.stiegert@ecb.int.

3 Warwick University, CSGR and CEPR, Address: Department of Economics, Warwick University, Coventry CV4 7AL, UK, E-mail: marcus.miller@warwick.ac.uk.

Address	**Kaiserstrasse 29**
	D-60311 Frankfurt am Main
	Germany
Postal address	**Postfach 16 03 19**
	D-60066 Frankfurt am Main
	Germany
Telephone	**+49 69 1344 0**
Internet	**http://www.ecb.int**
Fax	**+49 69 1344 6000**
Telex	**411 144 ecb d**

ISSN 1561-0810 (print)
ISSN 1725-2806 (online)

Contents

Abstract: Over the past decades, cross-border financial flows have increased in importance and have in many occasions exceeded the underlying current account positions. This phenomenon has been accompanied by an increase in the volume of international equity transactions that accentuate the role of international risk sharing as a factor for the macroeconomic response to shocks. We use a stylised two-bloc, two-period model of the global economy, with a simple stochastic productivity shock affecting only one country. Efficient global risk-sharing imply that expected productivity gains in one country will attract equity inflows in excess of those needed to finance the current account. Upward-biased expectations about prospects for the productivity gains can further increase the risk exposure of foreign shareholders. The model is calibrated to show how *ex post* market losses – whether due to "normal" stock market downturn or *ex ante* over-optimism – are distributed and how they affect global consumption and current account positions. The results suggest that international spillover effects of stock market bubbles can contribute to business cycle synchronisation across economic areas.

JEL Classification: F41, F32, G15
Key words: Capital flows, consumption smoothing, risk aversion, international risk-sharing, international business cycle synchronisation.

Non-technical Summary

In a speech delivered in October 2002, Alan Greenspan, the Chairman of the Federal Reserve, highlighted the ways financial assets can smooth consumption across different states of nature, and not just over time. To illustrate the importance of such risk sharing, he cited the steadiness of the US economy in face of "the draining impact of a loss of USD 8 trillion of stock market wealth" and other adverse shocks throughout 2001-02. The fact that the US productivity boom in the 1990s was to a large extent financed by equity implies that the subsequent decline in asset valuations was largely absorbed by the shareholders and distributed broadly, thereby avoiding – unlike in the case of bond or credit financing that imply fixed payments from debtors – a concentration of risks in the corporate sector. However, our analysis focuses on the increasingly important international dimension of risk sharing, as motivated by the sharp rise in international flows of FDI and equity investment throughout the past decade. Indeed, international capital flows in the 1990s far exceeded the amounts associated with the underlying current account considerations – causing large imbalances in global basic balance positions – and allowed financial shocks to be transmitted internationally. These financial links could, in turn, have contributed to increased synchronisation of business cycles across economic areas.

Following Obstfeld and Rogoff (1996), the dynamic theory of balance of payments tends to focus on the role of financial markets in smoothing consumption over time in open economies. In the world of uncertainty, however, there are additional motives for financial flows due to risk sharing. Since there is no need to choose between consumption-smoothing and risk-sharing motives for capital movements, we build a model that takes into account the international risk sharing associated with a productivity boom in one part of the world. We adopt a simple two-country, two- period framework where the efficient portfolio choice between risk-free debt and risky equity is endogenised. The most convenient way of determining efficient asset allocation under uncertainty is by positing the existence of the so-called Arrow securities, each of which pays one unit of the consumption good in a specific state. For example, a risky equity share, which only pays out in the good state, can be interpreted as one Arrow security; in a world of two possible states only, fully collateralised, index-linked debt promising one unit in both states would amount to the sum of two Arrow securities. One then proceeds to find the Arrow-Debreu

prices which clear the markets for such securities. These prices can then be used to evaluate more conventional securities, interpreted as combinations of the basic Arrow securities.

We note first that in the presence of stochastic expectations of higher future economic growth, efficient risk allocation implies substantial *ex ante* financial transactions over and above those needed to finance the current account. In particular, we illustrate how investors expecting rapid future growth in the home economy are able to hedge part of their risk by selling equity shares and buying foreign bonds. We also show that the size of the international risk sharing flows are dependent on assumptions regarding investors' *ex ante* optimism vis-à-vis future economic growth prospects, in line with the "irrational exuberance" argument as was suggested by Shiller (2000). Finally, we note that equity finance can generate significant *ex post* wealth transfers across the world very different from those associated with debt finance. A central implication of our work is that an anticipated supply side shock that fails to materialise *ex post* has asymmetric implications on global wealth positions depending on the assets involved in the *ex ante* capital transfers.

Taking as an example the US "New Economy" boom in the 1990s, had the US financed its widening current account deficit with fixed coupon debt US consumers alone would have had to absorb the full force of the market fall after part of the perceived productivity gains of the 1990's evaporated since late 2000. But because the US external deficit was to a large extent financed through foreign purchases of US equity shares, part of the losses generated from stock market correction in the US were distributed abroad. Our model calibration results suggest that the model is capable of producing wealth losses of the magnitude experienced by the US after the burst of the "New Economy" bubble within a reasonable range of parameter values that are also consistent with previous research. It also turns out that a significant share of these *ex post* wealth losses is transmitted abroad with implications on consumption and economic growth globally.

"If risk is properly dispersed, shocks to the overall economic system will be better absorbed and less likely to create cascading failures that could threaten financial stability." Alan Greenspan, Lancaster House, London, October 2002.

1. Introduction

With an emphasis on the risk-sharing role of the financial system in his address on "World Finance and Risk Management" in October 2002, Alan Greenspan, the Chairman of the Federal Reserve, highlighted the ways financial assets can smooth consumption across different states of nature, and not just over time. To illustrate the importance of such risk sharing, he cited the steadiness of the US economy in face of "the draining impact of a loss of USD 8 trillion of stock market wealth" and other adverse shocks throughout 2001-02. From the perspective of risk sharing, the debt/equity ratio is a key feature: the fact that the US productivity boom in the 1990s was to a large extent financed by equity implies that the subsequent decline in asset valuations was largely absorbed by the shareholders and distributed broadly, thereby avoiding – unlike in the case of bond or credit financing that imply fixed payments from debtors – a concentration of these risks in the corporate sector, with possible implications for macroeconomic reactions to the shock.

The international dimension of risk sharing and the associated international capital flows were not stressed by the Fed Chairman. But they are central to our analysis, motivated by evidence of a surge in the second half of the 1990s in international financial flows with substantial implications for the global financial markets. The economic region in the centre of attention in this respect was the United States which, spurred by the productivity boom driven by the "New Economy" considerations, has been running a significant current account deficit for a protracted period of time (see Table 1).[2]

[2] In particular, during the period 2000-2002 the US current account deficit-GDP ratio averaged 4.3%, which is the highest level in the last 20 years.

Table 1: The financing of the US current account

USD bn	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Current account	-118	-128	-204	-293	-410	-393	-503
Net flows in US securities*	221	171	45	158	281	337	414
Net direct investment	-5	1	36	101	130	3	-93

**Including foreign official investment in US Government Securities*

The financing side of the US BoP reveals that in the late 1990s net inflows to the US in combined foreign direct and total portfolio investment in several years exceeded the underlying current account positions, thus generating a surplus in the US basic balance.[3] Moreover, the breakdown of the portfolio flows reveals that equity inflows to the United States increased strongly up to 2000, at the time when the "New Economy" arguments were forcefully being put forward in the financial press.[4] In 2001-02, amid the global economic slowdown and the general decline in global financial flows, the composition of the US portfolio inflows changed with the share of equity flows falling sharply relative to flows in bonds. This development was mostly a reflection of the burst of the bubble in the equity markets on one hand, and the large capital gains on bond holders that were caused by the decline in US nominal interest rates on the other hand.

Following Obstfeld and Rogoff (1996), the dynamic theory of the balance of payments tends to focus on the role of financial markets in smoothing consumption over time in open economies. Bailey, Millard and Wells (henceforth BMW, 2001) have analysed the recent US productivity boom from this perspective. They argue that higher future income in the US, due to an

[3] The basic balance is here defined as the sum of the current account, direct and portfolio investment. A basic balance surplus means that a country is exporting financial assets in excess of its current account deficit, or, despite running a current account surplus. On the other hand, a basic balance deficit is financed mainly through net external liabilities of the home country's MFIs. For instance, sellers of US securities keep their proceeds as a deposit with a US affiliate of a purchaser country MFI. In economic terms, the purchase of foreign assets is then financed by credit.

[4] The main driving force behind the optimistic US growth expectations and the associated surge in equity prices in the late 1990s was the fact that US productivity growth accelerated sharply since 1995, growing at an average rate of 4.8% per year in 1995-99 as compared to 2.7% per year in 1980-94. At the same time, changes in global savings behaviour and pension funds regulations, investment flows from emerging markets after the 1997-98 crises, as well as the international diversification effects due to the formation of the EMU and the associated increase in correlation across euro area stock and bond markets, could all have acted as a "push factor" for equity flows to the US. See also IMF (2001).

anticipated productivity shock, leads a deficit on current account as US consumption rises in anticipation of future income gains.[5] In the world of uncertainty, however, shocks are stochastic rather than deterministic. In such circumstances, there are additional motives for financial flows due to risk sharing. Since there is no need to choose between consumption-smoothing and risk-sharing motives for capital movements, we extend the BMW approach by taking into account the international risk sharing associated with a productivity boom in one part of the world.[6]

For consistency with BMW, and for clarity of exposition, we continue with the two-country, two-period framework.[7] We note first that in the presence of stochastic expectations of higher future economic growth, efficient risk allocation implies substantial *ex ante* financial transactions over and above those needed to finance the current account. Second, efficient risk sharing implies that the consumers in the fast growing region sell risky equity shares to buy risk-free fixed income assets that provide guaranteed consumption in all states of the world. Third, we note that equity finance can generate significant *ex post* wealth transfers across the world very different from those associated with debt finance. This might also have implications for the international transmission of shocks, and could be a factor behind the recent increase in international business cycle synchronisation. Furthermore, in the simulations that accompany our analysis, we seek to incorporate aspects of market psychology such as the "irrational exuberance" decried by Mr Greenspan in 1996 and brilliantly dissected by Shiller (2000) in his best-selling book of that name.

This paper proceeds as follows. In section 2 we discuss, in non-technical fashion, first, the intertemporal implications of an anticipated supply side shock on the current account, and second, the implications for capital flows of incentives to spread the risks of investment in risky equity assets internationally. In section 3 we introduce a simple stochastic dynamic equilibrium

[5] In a recursive exercise, BMW noted that to the extent that productivity gains were concentrated on the tradable goods sector, the widening gap in relative income and consumption in favour of US consumers would also have lead to a real appreciation of the US dollar via the Balassa-Samuelson effect. In this context, the actual driving force behind exchange rate movements are the expectations regarding future relative economic growth and capital flows serve as the counterpart of the international consumption smoothing exercise. See Tille (2001) and Meredith (2001).

[6] In their classic study of general equilibrium, Arrow and Debreu included a complete set of contracts running through time and across all states.

[7] See De Fiore and Liu (2002) for a more general framework where risk sharing is modelled in the context of differentiated traded goods and a more general consumer utility function.

model for consumption and investment, with optimal portfolio allocation between equity and debt. In section 4 the model is numerically calibrated to fit the stylised facts of the US growth rates and equity valuations over the 1990s and the early 2000s. Section 5 concludes.

2. Growth Expectations and International Asset Allocation

Our aim is to try to address the following two questions. First, what are the economic determinants that may generate capital flows between the home and foreign economies that correspond to the particular composition and magnitude recorded between the US and the rest of the world in the late 1990s? Second, in the presence of a large-scale foreign participation in the home country equity market boom, what are the real economy implications to the home and the foreign economies of the burst of a stock market driven bubble in the home country? The model we use is designed to analyse the implications for current and planned consumption in the home and foreign country, following an anticipated productivity shock in the home country that does not, ultimately, materialise as forecast. In a two-region model where the home country trades with a foreign country, a productivity shock at home is shown to have important repercussions on foreign consumption patterns via the current and capital accounts. The full analytical derivation, including details of the stochastic productivity shocks, is to be found in the next section. However, since the intuition behind the combined time and state dimensions of the shocks in the model might not be easily grasped from the equations, in this section we use graphical analysis to illustrate the key elements.

A reader's guide to our approach is given as follows. We first consider the impact of shocks of uncertain size in a two-period framework where the current account deficits caused by international *consumption-smoothing* are financed either with debt or equity. Then, we discuss the *risk-sharing* rationale for capital flows, which involves the home country residents swapping equity for foreign debt. This leads to the specification of a simple two-country, two-period stochastic model encompassing both consumption smoothing and risk sharing motives.

2.1. Pure debt financing

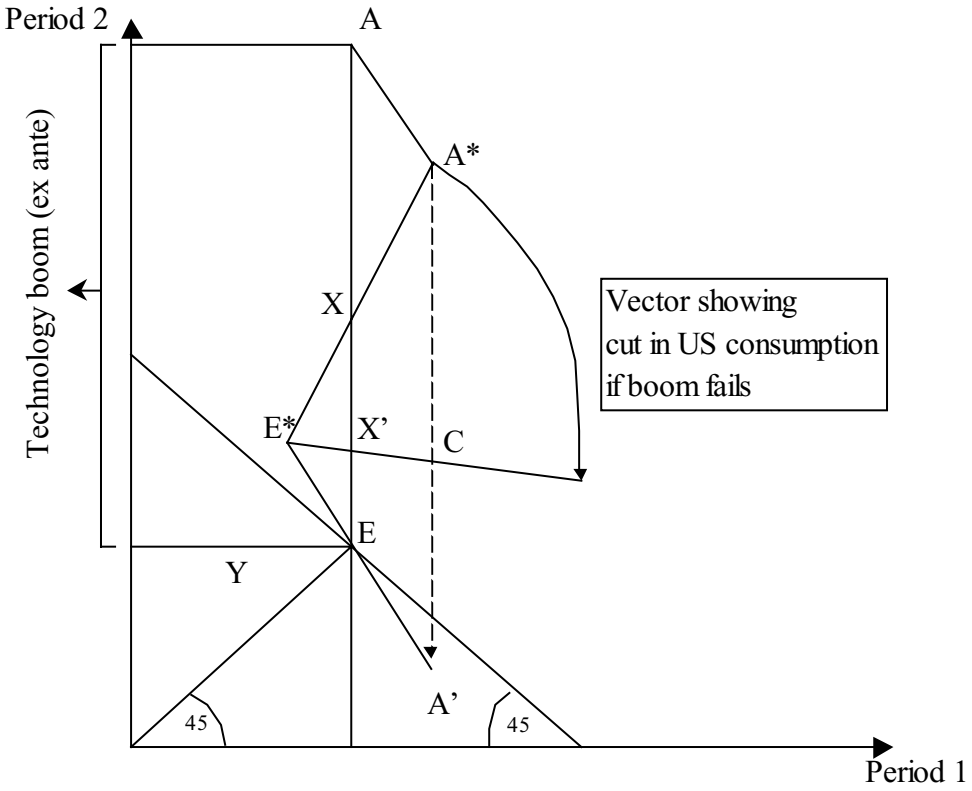
To start with, the logic of the two-country, two-period, single traded good deterministic framework of the BMW (2001) consumption smoothing approach can be illustrated in a simple "Fisher diagram". Chart 1 plots the first-period income endowments for both countries horizontally and the second period outcomes vertically. In the absence of a shock the two countries have the same endowments in both periods, as shown by the point *E*. Assuming identical preferences, there will be no trade so each country will choose to consume at point *E*.[8]

Imagine now that the home economy is subject to a productivity shock that increases the second period income and consumption possibilities. This shock moves the home endowment point vertically up to point *A,* while the foreign residents' endowment remains at point *E.* Trade and capital flows are now induced by the different endowments. The home country consumers can shift some consumption to period 1 by running an initial current account deficit and repaying it later, as shown by the consumption point *A*.* To induce the foreign consumers to reduce period 1 consumption and finance the home country's current account deficit requires a rise in world interest rate. This is indicated by the increased steepness of the budget lines linking *A* and *A** and *E* and *E*,* where *E** represents trade-induced consumption in the foreign country. World consumption, shown by the point *X* midway between *A** and *E*,* matches average endowment as *X* lies midway between *A* and *E.*[9]

[8] For clarity of exposition, point *E* is plotted on the 45 degree line and the budget constraint has a slope of minus 1. That is, we ignore underlying growth and pure time preference in the figure.

[9] Strictly speaking, the presence of uncertainty in the model does that with risk-averse consumers, the extent of international consumption smoothing will be slightly smaller and the increase in the international rate of interest lower than illustrated in the simple diagram.

Chart 1: Intertemporal consumption smoothing with pure debt financing



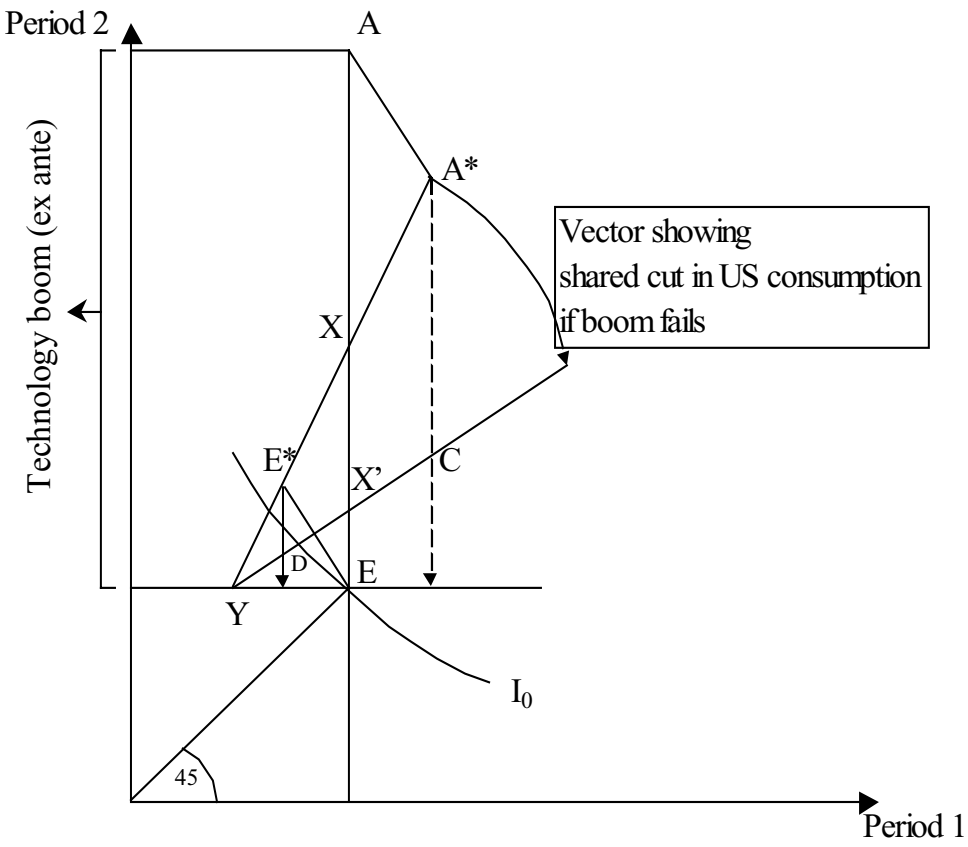
In their model, BMW (2001) assume perfect foresight so that the consumption plan will be realised. But what happens if the productivity increase in fact turns out to be much smaller than forecast? The answer depends importantly on how the deficits are financed. If the home current account deficit was financed by foreign residents buying fixed income bonds issued by the home country, then an anticipated boom that does not materialise will reduce the second period consumption in the home country, leaving the foreign consumption unscathed. Graphically, in the extreme case where there turns out to be no shock at all, this involves shifting the point *X* vertically down to *E,* leaving foreign consumption unchanged at *E** but cutting consumption in the home country to *A'*. The foreign consumers are left with increased utility from the capital transfer re-paid with interest – but home consumers are worse off as a result of a costly exercise in "unsmoothing" consumption.

2.2. Pure equity financing

On the basis of the developments in the international capital flows over the past decade, as discussed in the introduction, it could be argued that pure bond financing is not the appropriate way to model international financial transactions, at least among developed economies. This is because risk-free debt would not offer the foreign investors a share in the benefits of the economic boom in the home country that is fuelled by significant productivity improvements. To achieve this, foreign residents would need to require risky equity shares rather than risk-free bonds as a payment for their financing of the home country current account deficit. However, any failure of the expected home country productivity shock to materialise *ex post* would in such a case lead to a cut in second period consumption also in the foreign country, while the home consumers would be spared some of the loss.

The outcomes in the case of pure equity financing are illustrated in Chart 2, where the endowments *E, A* and consumption points *E*, A** are as in Chart 1. If there is a failure of expectations, in the extreme case where there turns out to be no productivity shock at all, second period consumption both in the home and in the foreign country falls (the latter to point *D*). At point *D,* foreign consumers are worse off than in their initial endowment at *E* as they abstain from consumption in period 1 in exchange of receiving near worthless assets in period 2. Home country investors will lose all their second period excess income, but they will nevertheless be better off due to increased consumption in the first period.

Chart 2: Intertemporal consumption smoothing with pure equity financing



While this logic illustrates how the foreign consumers might be exposed to the developments in the home real economy through the equity market channel, the exposure is, by assumption, limited by the size of the current account surplus to be invested. Consequently, the extent to which the foreign consumers buy into the home market is drastically limited in comparison to the exposure of the home county consumers themselves. But when there is uncertainty regarding future payoffs, international risk sharing allows for efficient distribution of risky assets by capital flows that may exceed the underlying current account deficits.

2.3. Optimal portfolio asset allocation and international risk sharing

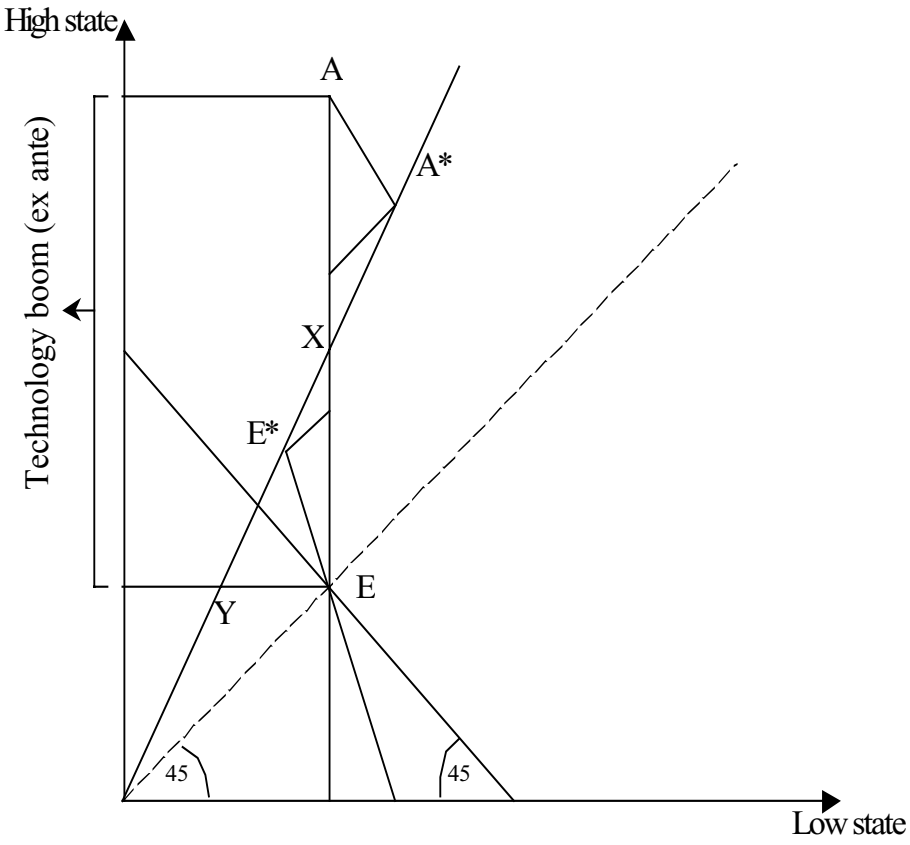
In the face of uncertainty, investors are unlikely to place all their funds in one asset. It is well known that efficient risk allocation generally calls for as many different securities as there are states of nature. In the current context, for efficient portfolio choice both risk-free debt and risky equity are required.

Technically, the simplest way of determining efficient asset allocation under uncertainty is by positing the existence of the so-called Arrow securities, each of which pays one unit of the consumption good in a specific state. For example, a risky equity share, which only pays out in the good state, can be interpreted as one Arrow security; in a world of two possible states only, fully collateralised, index-linked debt promising one unit in both states would amount to the sum of two Arrow securities. One then proceeds to find the Arrow-Debreu prices which clear the markets for such securities. These prices can then be used to evaluate more conventional securities, interpreted as combinations of the basic Arrow securities.

This method is used to derive the results reported in the next section, but we first illustrate the intuition by means of a one-period "state preference" diagram. Chart 3 leaves aside the intertemporal considerations covered in detail in Charts 1 and 2. Endowments and consumption in the "low growth" state are now plotted horizontally while the "high growth" state outcomes are plotted vertically. Assume again that, in the absence of the home country productivity shock, the home and the foreign consumers have the same endowments in both states (point *E).* Given identical preferences, both economic areas will choose to consume at point *E,* the point of tangency between the budget constraint and the indifference curve. Note that in the state-preference diagram, the slope of the indifference curve on the 45-degree line is given by $(1-\pi)/\pi$ where π is the probability of the good state occurring as perceived by investors.[10]

[10] For simplicity the budget constraint has a slope of minus 1 in the figure, i.e. $\pi = ½$. Since the consumers in both countries have the same preferences, any exchange in assets will be solely motivated by the need to smooth consumption across the two different states.

Chart 3: International risk sharing



Look now what happens if the home country is expected to experience a productivity shock. If the benefits of the shock accrue only in the "high" state, then the home endowment point moves vertically up to *A,* where the distance between *E* and *A* indicates the expected size of the home country productivity boom. Even in this a-temporal framework with uncertain state realisations, trade in assets may now be induced by different endowments as the home consumers/investors diversify risk by selling equities to the foreign investors in exchange for risk-free debt. From the home country's point of view, this outcome leads to consumption at point *A**. Point *E*,* in turn, represents planned consumption in the foreign country after the exchange in assets.[11] Foreign consumers are willing to reduce consumption if the scenario of low growth in the home country materialises, in order to benefit from substantial expected economic expansion if the home country growth turns out to be high. The steep slope of the budget lines linking *A* and *A** and *E*

[11] As in the intertemporal case, average consumption, shown by the point *X* midway between *A** and *E*,* matches average endowment as *X* lies midway between *A* and *E*.

and E^* indicates that a unit of consumption in the high state (where output is high) is less valuable than a unit of consumption in the low state (where there is no boom in home country). This shift in relative prices is sufficient to induce the foreign investors to buy high-tech shares and reduce consumption in the low state.

Consumers in both countries expect to be better off. The home consumers will benefit from a majority stake in an anticipated consumption boom plus the pay-off on the risk-free assets they purchase to reduce risk; foreign consumers look forward to profits from their stake in the home country boom, net of the leverage required to buy it. Note that leaving aside the intertemporal aspects means ignoring the role of the current account considerations in the trade of assets discussed above. Thus, the financial flows out of the foreign country in connection with risk sharing can occur independently of any possible foreign country current account surplus and need not in principle involve a change in interest rates.[12]

Note that Arrow-Debreu solutions considered in Chart 3 are essentially *ex ante* in that trade in assets takes place based on the *expected* size and probability of the boom driven by productivity shocks. How things turn out depends, of course, on how realistic were the expectations. If they were realistic, so that the expected growth rate (*i.e.,* average of the distribution) corresponds to the solution under perfect foresight (where there is no uncertainty), then the state contingent prices solved *ex ante* will correspond to the *ex post* prices where markets open for trade and the allocations chosen *ex ante* are good *ex post*.[13] If the expected growth rate differs significantly from the perfect foresight solution due to optimistic expectations, the *ex post* prices can differ and agents may wish to re-contract. This is consistent with the "irrational exuberance" story by Shiller (2000), where over-optimism led to investment strategies that, given the underlying fundamentals, were highly unrealistic. The model described in the next section combines the inter-temporal and cross-state incentives for consumption smoothing in an integrated equilibrium and it is solved both for the rational expectations equilibrium and irrational exuberance cases.

[12] It is clear that the home country will sell equity for debt in the special case shown in the diagram, where the productivity driven boom is entirely absent in the bad state. This 'insurance motive' diminishes the more the boom is expected to deliver on the downside as well. More specifically, if the low-state consumption level is measured as L, it can easily be verified that the insurance motive is relevant only when $L < \pi H$, where H is the size of the consumption boom in the good state and π is the probability of that occurring.

[13] See Mas-Collel et al (1995, Ch. 19) for a detailed discussion about state-contingent asset returns.

3. The Model

Based on the simple framework by BMW (2001), we derive a dynamic stochastic equilibrium model in which consumers maximise intertemporal utility and share risk internationally. The novelty in our approach is that due to the uncertain nature of the shocks, investment in the anticipated productivity boom takes the form of risky equity investment.

The model has two economies, home and foreign. In the first period, consumers in the home country expect that in the second period, they will enjoy growth rates above the trend due to an exogenous productivity improvement. The productivity shock is, however, stochastic and will only materialise with a probability less than one.

To capture the risky nature of consumption in an economy where future growth rates depend on uncertain productivity developments, one must allow for multiple payoffs and *ex ante* uncertainty. Here we take a simplistic approach by considering only two possible states of the world, high growth and low growth, occurring with probabilities that are fixed and known. Given the convexity of the preferences, consumers are risk averse. This implies that on one hand, the borrowers are faced with the prospect of large cuts in consumption if they must pay off their loans in the bad state where the positive productivity shock does not generate high incomes. On the other hand, the lenders also face a risk of a loss if the repayment of the loan is in shares of the expected economic boom. To make intertemporal transactions attractive in such an environment, the prices of the assets that provide consumption in different states of world much adjust endogenously.

Let there be two representative consumers, domestic and foreign. The two consumers face the following identical logarithmic utility functions (where asterisks denote foreign variables).

(3.1) a) $V = \ln c_1 + \beta[\pi \ln c_2^H + (1-\pi)\ln c_2^L]$

b) $V^* = \ln c_1\ ^* + \beta[\pi \ln c_2^H\ ^* + (1-\pi)\ln c_2^L{}^*]$

In (3.1), c_1 is period 1 consumption (out of the exogenously given endowment), c_2 is the consumption on period 2 and β is the consumers' (common) discount factor. In the second period, the home country is assumed to be subject to a stochastic positive productivity shock on the tradable goods sector. Due to international risk sharing, the second period consumption in both countries is therefore stochastic and can take two values, c^L (low consumption) and c^H (high consumption), with probability π assigned on the high consumption state.

In order to analyse the investor portfolio choice between risk-free and risky assets in the dynamic consumption environment, we extend the analysis to allow for Arrow-Debreu (A-D) securities. By providing state-contingent payoffs in period 2, A-D securities make the choice of consumption in different states analogous to the choice of consumption in different dates. If it is assumed that A-D securities exist for every possible state, risk free assets can also be incorporated in the analysis without explicit treatment of bond market in the model (as this would not affect the economy's equilibrium). Using this simple framework we can derive an outcome where the investors in two countries exchange risk so as to obtain higher cross-state utility. The relative prices of the two assets with different risk characteristics (units of consumption in the two states) must then adjust so as to facilitate trade and induce the trend-growing foreign country to take on some risk. The home consumers maximise (3.1b) subject to an intertemporal budget constraint that reads as follows.

$$
\begin{aligned}
& c_1 + p^H c_2^H + p^L c_2^L \\
& = y_1 + \alpha\bar{y} + p^H (y_2^H - \bar{y}) + p^L (y_2^L - \bar{y})
\end{aligned}
\tag{3.2}
$$

$$\alpha \equiv p^H + p^L = \frac{1}{1+r}$$

In (3.2), y_1 and y_2 denote the fist and second period output, respectively (with second period output taking two possible values), while $\bar{y}$ shows the trend output growth, assumed to be identical in the two countries. The equivalence between α, the sum of the prices of assets with different risk characteristics p^H and p^L, and the inverse of the risk free rate of return captures the idea that in a two-state framework, investment in the bond market (that is equivalent to the sum

of the A-D prices in the two states) delivers a payoff that is consistent with the output growing along the trend.

The foreign consumers' budget constraint is slightly different than that of the home consumers, reflecting the idea that the home consumers are directly exposed to the expected benefits from the productivity driven growth boom.

(3.3) $$c_1^* + p^H c_2^{H*} + p^L c_2^{L*} = y_1^* + \alpha\bar{y}$$

In anticipation of a positive productivity shock in period 2, in the first period the domestic consumers prefer to consume in excess of their income endowment y_1, thus borrowing from the foreign country to cover the corresponding current account deficit. In the second period, the domestic consumers enjoy the second period income minus the consumption loan to be repaid to the foreign consumers. The domestic consumers choose first-period consumption to maximise their utility (3.1) with respect to the budget constraint (3.2). The problem can thus be formulated as the following Langrangean condition (symmetric formulation holds for the foreign consumers).

(3.4) $$L = \ln c_1 + \beta[\pi \ln c_2^H + (1-\pi)\ln c_2^L] + \lambda(\cdot)$$

The term multiplied by λ incorporates the budget constraint (3.2) ((3.3) for the foreign country). Although the budget constraints are different for the two countries the first order conditions are, nevertheless, the same. Hence we can solve for the home consumers' Keynes-Ramsey rules for the high and the low states of tradable goods consumption in the second period as follows (the outcomes for the foreign consumers follow by symmetry):

$$\frac{\partial L}{\partial c_1} = \frac{1}{c_1} + \lambda = 0 \Rightarrow \lambda = -\frac{1}{c_1}$$

$$\frac{\partial L}{\partial c_2^H} = \frac{\pi\beta}{c_2^H} + \lambda p^H \Rightarrow \frac{c_2^H}{c_1} = \frac{\pi\beta}{p^H} \tag{3.5}$$

$$\frac{\partial L}{\partial c_2^L} = \frac{(1-\pi)\beta}{c_2^L} + \lambda p^L \Rightarrow \frac{c_2^L}{c_1} = \frac{(1-\pi)\beta}{p^L}$$

From (3.5), we see that in the stochastic case, the Keynes-Ramsey rule gives two separate values for the expected growth of domestic consumption from period 1 to period 2, depending on the probability of the high output state realising in period 2. Since the Keynes-Ramsey rules for both countries are identical, the global equilibrium in our two-country framework can be defined by combining (3.5) with the expected growth of consumption in the foreign country. When the two countries are symmetric and of equal size, the A-D prices adjust so that the boom in the home country, driven by expected productivity growth, rises the world output in period 2 by half that amount. Since in our set-up the growth rate of world output equals the growth rate of world consumption, world consumption will also increase by half the amount of the domestic output growth. Due to this symmetry, the second-period consumption growth will thus be the same in both economic areas although no boom is anticipated in the foreign country. From the Euler equations that determine the global equilibrium conditions under the two states, it is then straightforward to solve for the A-D asset prices in the high and low consumption states.

$$\frac{\beta\pi}{p^H} = 1 + g + \frac{s^H}{2} \Rightarrow p^H = \frac{\beta\pi}{1 + g + \frac{s^H}{2}}; \quad s^H = \frac{y_2^T - \bar{y}}{\bar{y}}$$

$$\frac{\beta(1-\pi)}{p^L} = 1 + g + \frac{s^L}{2} \Rightarrow p^L = \frac{\beta(1-\pi)}{1 + g + \frac{s^L}{2}}; \quad s^L = \frac{y_2^T - \bar{y}}{\bar{y}} \tag{3.6}$$

$$\therefore p^H < p^L$$

The right hand sides of the Euler equations (3.6) consist of the growth rate g originally expected in both countries, as well as the additional growth $y_2{}^H$ or $y_2{}^L$ above the trend level $\bar{y}$ that is generated by the second-period boom in the home country.

A few words are warranted about the role played by the A-D prices in driving the equilibrium asset allocation decision. Assuming that the two states occur with the same prior probability, the price of the low-state asset (a unit of consumption in the case where a smaller shock will materialise) is higher than the price of the high-state asset, indicating that a unit of consumption in the low state is relatively more valuable. Hence, the owner of the low-state asset has to receive more than one unit of the high-state assets in exchange of abstaining from one unit of consumption in case the low state occurs. More generally, the ratio between the contingent price and the probability of the corresponding state is smaller for the state in which the resource is less scarce.[14]

Having solved for the consumer's intertemporal problem, it is now possible to solve for the level of consumption in the two different periods in the two countries. We can use the properties of the Cobb-Douglas type utility function (3.1) where, by construction, exponents equal the expenditure shares across the two periods. Starting from the foreign country, and recalling that income equals consumption in our model, we obtain the following expression for the first-period tradable goods consumption.

$$c_1^* = \frac{1}{1+\beta}(y_1^* + \alpha y_2^*)$$

Remember that for the foreign country, $E(y_2^*) = \bar{y}$ and $\bar{y}/y_{1^*} = 1+g$. The above expression can then be re-written as

$$\frac{c_1^*}{y_1^*} = \frac{1}{1+\beta}[1+\alpha(1+g)] \tag{3.7}$$

The extent to which consumers in the foreign country will cut their first-period consumption and run a current account surplus in the first period is the larger the lower is α. This is in turn inversely related to the price of the asset providing one unit of consumption in the low-growth

[14] See for example Malinvaud (1983) for derivation of the Arrow-Debreu prices in a theoretical context.

state. Therefore, in the foreign country, first period consumption is defined by the endogenous A-D prices stipulated by the right-hand sides of equation (3.7). Using the expenditure shares for the two possible states in the second period, we get:

$$p^H c_2^H * = \frac{\pi\beta}{1+\beta}(y_1 * + \alpha\bar{y}) \Rightarrow \frac{c_2^H *}{y_1 *} = \frac{\pi\beta}{p^H}\frac{c_1 *}{y_1 *}$$

$$p^L c_2^L * = \frac{(1-\pi)\beta}{1+\beta}(y_1 * + \alpha\bar{y}) \Rightarrow \frac{c_2^L *}{y_1 *} = \frac{(1-\pi)\beta}{p^L}\frac{c_1 *}{y_1 *} \quad (3.8)$$

For the home country, the consumption allocations in period 1 and in the two possible states in period 2 are given by the following conditions:

$$\frac{c_1}{y_1} = \frac{1}{1+\beta}[1 + \alpha(1+g)(1 + p^H s^H + p^L s^L)]$$

$$\frac{c_2^H}{y_1} = \frac{\pi\beta}{p^H}\frac{c_1}{y_1}$$

$$\frac{c_2^L}{y_1} = \frac{(1-\pi)\beta}{p^L}\frac{c_1}{y_1} \quad (3.9)$$

As in the foreign country, consumption in the home country is directly dependent on the expected growth in the second period. In addition, the first period consumption level is decreasing in β, the value attached by domestic consumers on the utility from future consumption expenditure.

4. Numerical Calibration of the Model

We now turn to analyse the outcomes of the model on income, consumption and international asset allocation, taking as a refernce point the US "New Economy" boom in the late 1990s and the early 2000s. In the baseline scenario, we draw from the outcome presented by the BMW (2001) and show how their results can be obtained as a special case of our stochastic framework. We then proceed to simulations under various assumptions regarding investors' expectations about the "New Economy", and show how the outcomes in the US and in the rest of the world will play out if the expectations do not materialise *ex post.* Finally, we capitalise the flows in various scenarios to assess what these might imply in terms of losses as percentage of US GDP.

4.1. Baseline case

Following BMW (2001), we assume that the expected "New Economy" boom in the US is a once-and-for-all 5.0% increase in the level of the US GDP, leaving trend growth unchanged at 2.4%. Given the stochastic nature of our model, we take this expected payoff to be the mean (average) of two equi-probable outcomes, a low pay-off of 3%, and a high pay-off of 7%. Thus, if it is the low payoff that is observed *ex post,* then the market would fall by almost a half, although the "New Economy" will still allow the US economy to grow 3% above the trend. Given rational expectations this downside risk would, however, have been perfectly foreseen and balanced by the upside prospect of the market rising by almost a half. Consequently, the expected (average) 5% increase coincides with the perfect foresight solution.

Table 2: Baseline with Rational Expectations

(A): Payoffs, state contingent prices, the stock market and the interest rate

π=1/2	s^H	s^L	p^H	p^L	X	R
Probability of s^H	High payoff	Low Payoff			Stock market	Interest rate
0.5	7.0%	3.0%	0.465	0.474	4.7%	6.5%

(B): Consumption, borrowing, shares and the real exchange rate.

	C_1	C_2^H	C_2^L	Debt issued (% GNP)	Shares held (% GNP)
Foreign country	-1.2%	4.6%	2.7%	1.1	2.3
US	1.2%	7.2%	5.1%	-1.1	2.4

The key to the symbols used in the table is as follows. π is the probability that the high growth state occurs. S^H and S^L are the growth rates above the 2.4% trend growth in the high and the low states, respectively. P^H and P^L are the Arrow-Debreu prices that drive the investment decisions across asset categories, with P^H measuring the price of the asset that provides consumption in the high growth state. X denotes the increase in the value of the US stock market as a result of the expected higher economic growth. R is the world interest rate that adjusts so as to induce the investors to trade and smooth their consumption across periods. C_1 shows consumption in period 1, with a negative number indicating a current account surplus. Finally, C_2^H and C_2^L denote the state-dependent consumption outcomes in the second period, including the trend growth rate.

The resulting interest rate of 6.5% is shown in the last column of Table 2A. Together with the implied current account positions of 1.2% (surplus for the foreign country, deficit for the US, shown in the first column of Table 2B), these outcomes closely match the results in BMW. What these simulations also provide (in the remaining columns of Table 2B) are the consumption plans made to cope with uncertainty, and the optimal asset positions taken to implement them. In particular, given the 2.4% trend growth rate per period, the US gives up 2.2% of the potential second-period consumption in the good state (from 2.4% + 7.0% = 9.4% to 7.2%) so as to ensure that in the low state consumption is 2.7% above the 2.4% trend growth rate (2.4%+2.7%=5.1%). This consumption level is, however, 0.3% lower than the *ex ante* low state payoff (2.4%+3.0%=5.4%); despite some risk sharing, in the low state the US consumers suffer from overinvestment and failed consumption smoothing as the asset returns do not provide a full insurance against economic downturn. For the foreign country, in the low state, at 2.7%

consumption slightly exceeds trend GDP growth and reaches almost twice the trend growth in the high state (*i.e.,* 2.4%+2.2%=4.6% above base period GDP).

How are the relative changes in consumption and asset allocation achieved? In the first place there is the *inter-temporal* consumption-smoothing emphasised by BMW (2001), where the US runs a current account deficit of 1.2% of GDP in the first period, which, if it takes the form of equity sales, involves selling approximately a quarter of the expected "New Economy" boom (that in total amounts to 5% of GDP). But in addition there is the *insurance* motive where the US trades some of its risky payoffs in exchange of a more certain flow of income and consumption. In the calibrations to follow, these motives are further stimulated by optimistic expectations, but even the rational expectations solution in the baseline scenario strikingly illustrates the incentive for risk-sharing. Indeed, at 2.3% of GDP (see column "shares held") the amount of US shares purchased by foreigners is nearly twice as high than is required to finance the US current account deficit. In other words, in addition to investing the current account surplus of 1.2% of GDP in risky US assets, the US's partner in trade borrows another 1.1% of the GDP (see column "debt issued") to acquire altogether almost half of the value of shares in the US "New Economy". In sum, in the benchmark scenario the US consumers suffer some loss from the failed intertemporal consumption smoothing if the economic growth in the second period turns out to be lower than expected. Foreign consumers, on the other hand, will be better off independent of the realisation of the state of nature.

4.2. Irrational exuberance

In his book titled "*Irrational Exuberance"*, Shiller (2000) argued that for a variety of reasons – including the "New Era Economic Thinking" and "Herd Behaviour" – the US stock market became seriously overvalued in the late 1990s. To characterise the implications of such overly optimistic market expectations, we increase the perceived high state pay-off to 9.0%, leaving the low state payoff unchanged. This raises the expected, or average, US boom from BMW's 5% to a 6.0% increase over the trend growth rate. In this case, if the low state payoff materialises, the market should fall by about two thirds.[15]

[15] However, it could be argued that an "irrational expectations" scenario becomes "irrational" only *ex post* if the expectations are vastly disappointed. If the things turned out as planned, the *ex ante* consumption decisions and asset

Table 3: Irrational Exuberance

(A): Payoffs, state contingent prices, the stock market and the interest rate

π=1/2	s^H	s^L	P^H	P^L	X	R
Probability of sH	High payoff	Low Payoff			Stock market	Interest rate
0.5	9.0%	3.0%	0.460	0.474	5.6%	7.1%

(B): Consumption (plans in brackets), borrowing, shares and the real exchange rate.

	C_1	C_2^H	C_2^L	Debt issued (% GNP)	Shares held (% GNP)
Foreign country	-1.4%	(5.5%)	(2.4%) 2.4%	1.3%	2.7%
US	1.4%	(8.5%)	(5.4%) 5.4%	-1.3%	2.9%

The key to the symbols used in the table is as follows. π is the probability that the high growth state occurs. S^H and S^L are the growth rates above the 2.4% trend growth in the high and the low states, respectively. P^H and P^L are the Arrow-Debreu prices that drive the investment decisions across asset categories, with P^H measuring the price of the asset that provides consumption in the high growth state. X denotes the increase in the value of the US stock market as a result of the expected higher economic growth. R is the world interest rate that adjusts so as to induce the investors to trade and smooth their consumption across periods. C_1 shows consumption in period 1, with a negative number indicating a current account surplus. Finally, C_2^H and C_2^L denote the state-dependent consumption outcomes in the second period, including the trend growth rate.

Compared with the baseline scenario, interest rates rise by just over half a percentage point as foreign investors provide additional funds for US consumption in exchange of shares in the "New Economy". In addition, the current account surplus in the foreign country and the leveraged position taken by the foreign investors increase to 1.4% and 1.3% of GDP respectively (see first and fourth columns of Table 3B).

What happens when the "New Economy" fails to materialise as expected and the low payoff is observed, is shown in the second and third columns of Table 3B where the *ex ante* consumption

allocations to finance them would turn out perfectly rational. Nevertheless, since the phrase originates from the famous speech by Greenspan in 1996 the scenario we adopt is, while purely illustrative, supported by the fact that at least in some circles the valuations were perceived excessive already prior to the stock market reached its peak in 2000.

plans are given in parentheses.[16] Specifically, US consumption is now about one third of a percentage point higher than it was in the baseline, while the foreign consumption is correspondingly lower. Strikingly, therefore, despite having saved in period one, foreign residents suffer a fall in second period income and consumption to the simple trend growth rate when leveraged bets go bad. However, from the point of view of foreign investors the outcome was planned for in advance (*i.e.* the risk was deliberately taken) as can be seen by the coincidence between the figures shown outside and inside the parentheses in Table 3B. This is simply because the *ex ante* probability of the irrationally high growth outcome was considered equally high than the probability of the low growth outcome. Again, it is important to recall that had the things materialised as planned, both US and foreign consumers would have gained a substantial boost in their second period incomes.

4.3. Irrational exuberance plus "meta moral hazard"

There is some evidence that – at least until late-2000 – investors could have believed that they were in some way insured against substantial losses in the US stock market (see SIPC, 2001). These mistaken beliefs could be referred to as "meta moral hazard", in part connected with the past actions of the US monetary authority.[17] To capture such optimism that extends to the downside, we let investors believe that they can do *no worse* than a 3.5% GDP growth payoff, even when the true low state payoff remains unchanged at 3.0% above the trend growth. With upside prospects boosted by "irrational exuberance" as in the previous example and downside payoffs artificially lifted by "meta moral hazard", the market could be set for a rude awakening if the payoff turns out to be only 3.0% above the trend growth rate.

[16] Note that in this scenario it is assumed that the *ex ante* consumption plans are the same than the realised outcomes in both the high and low growth states, and the outcomes inside and outside the parenthesis therefore always match. In the next scenario this assumption is relaxed and we consider the case where the true low state outcome may differ from the perceived one.

[17] More specifically, in the case of the US stock market in the late 1990s, this phenomenon was encapsulated in the idea of a "Greenspan put" – the notion that the US Federal Reserve, by limiting the market crash of 1987 and the liquidity crunch of 1998, may have made people feel they would automatically be provided the sort of downside protection normally achieved by buying a put option (see Miller and Weller, 2001).

Table 4: Irrational exuberance and "meta moral hazard"

(A) Payoffs, state contingent prices, the stock market and the interest rate

π=1/2	s^H	S^L	P^H	P^L	X	R
Probability of s^H	High payoff	Low Payoff			Stock market	Interest rate
0.5	9.0%	3.5%	0.460	0.473	5.8%	7.2%

(B) Consumption (plans in brackets), borrowing, shares and the real exchange rate

	C_1	C_2^H	C_2^L	Debt issued (% GNP)	Shares held (% GNP)
Foreign country	-1.5%	(5.4%)	(2.6%) 1.6%	1.4	2.9
US	1.5%	(8.5%)	(5.7%) 5.4%	-1.4	2.9

The key to the symbols used in the table is as follows. π is the probability that the high growth state occurs. S^H and S^L are the growth rates above the 2.4% trend growth in the high and the low states, respectively. P^H and P^L are the Arrow-Debreu prices that drive the investment decisions across asset categories, with P^H measuring the price of the asset that provides consumption in the high growth state. X denotes the increase in the value of the US stock market as a result of the expected higher economic growth. R is the world interest rate that adjusts so as to induce the investors to trade and smooth their consumption across periods. C_1 shows consumption in period 1, with a negative number indicating a current account surplus. Finally, C_2^H and C_2^L denote the state-dependent consumption outcomes in the second period, including the trend growth rate.

The first period US current account deficit now rises slightly to 1.5% of the GDP. Compared to the "irrational exuberance" scenario, foreign leverage rises further and interest rates rise by another tenth of a percentage point. What happens when the bubble bursts and there turns out to be no "safety net" provided by monetary policy? While the investors wrongly believe that they are insured, outcomes in the low state will now involve revising *ex ante* plans downward, as is shown in Table 4B where the *ex ante* consumption plans are again given in parenthesis. Specifically, instead of rising above trend GDP as planned, foreign consumption in the second period falls even further – despite the increased savings made in period one. In the US, while plans for consumption also suffer a setback in the low state, at 5.4% the actual consumption would still be 3% above the trend growth rate.[18]

[18] Note that our simplified model assumes that the US and the world interest rates are always the same. This implies, of course, that the model formulation neglects the explicit aspects of domestic monetary policy. If the US monetary authority would prevent the rise of real interest rates by accommodating the productivity increase and cutting nominal interest rates, the incentives for international asset transaction could be reduced.

4.4. Losses in the US stock markets and their international spillovers

It has been estimated that by late 2002, the losses on the US equity market from its peak two years earlier amounted to US dollar 8 trillion.[19] In this section we capitalise the flows discussed in the previous sections to see what they might imply about the size of the market fall and the relative contribution of three factors: normal market downturn (bad luck; in the baseline case), irrational exuberance, and meta moral hazard.

Bad luck plays a key role in the Baseline scenario when the outturn lies below the (true) mean value incorporated in market expectations. We use the Arrow-Debreu prices to value the market *ex ante* as they take account of both the distribution of possible out-turns and of the delay before they occur; but these are applied to the flows after they have been capitalised. The first column of Table 5 shows the flow values in period two – a high of 7% or a low of 3 % – and the capitalisation factor used, namely the sum of the pure rate of time preference and a risk premium of 4.3% estimated for the US market by Cechetti et al (2000). The market valuation of 81% of GDP shown in the third row comes from summing these discounted capital values. Since US GDP in 2002 was approximately US dollar 10 trillion, this implies a perceived *ex ante* nominal valuation of the US New Economy at US dollar 8.1 trillion.

[19] See Greenspan (2002).

Table 5: Stock Market Values and Estimated Losses
(Mean expected New Economy effect = 5.0% of US GDP)

		Flows, Second Period	Stocks,* second period	Arrow/ Debreu Prices	Valuation in first period	Dollar Values $trillion	Non - US Losses
A	**BASELINE**						
1	High payoff	7.0	121	0.465	56		
2	Low payoff	3.0	52	0.474	25		
3	Expected payoff	5.0			81	8.1	
4	Actual Payoff	3.0	52	0.948**	49	4.9	
5 = 3-4	Losses				32	3.2	1.6
B	**IRRATIONAL EXUBERANCE**						
3B	Expected payoff	6.0			96	9.6	
5B = 3B-4	Losses				47	4.7	2.4
C	**META MORAL HAZARD**						
3C	Expected payoff	6.25			100	10.0	
5C=3C-4	Losses				51	5.1	2.6
Memo items	Loss estimates					8.0 5.0***	0.5***

Notes:
** The discount rate used for capitalisation, in percentage points, is 5.8 = 1.5 + 4.3, where 1.5% is the rate of pure time preference – as for BMW – and 4.3% is the risk premium in US stock market estimated by Cechetti et al (2000).*
***The discount factor used in valuing the actual payoff is 0.948 = 1/(1.015)(1.024)(1.015) where*

- *1.5% is the rate pure time preference – matched with BMW;*
- *2.4% is the trend growth rate – matched with BMW;*
- *1.5% is the low outturn for the New Economy expressed as a fraction of World GDP.*

****Estimated losses from New Economy, in the case of non-US losses euro area only.*
All numbers as % of US GDP, unless otherwise specified. US nominal GDP in 2000 was approx. US dollar 10 trillion.

If US dollar 8 trillion were the correct *ex ante* valuation of the supply side shock, how much would the market fall if nature selects the lower of the two possible out-turns (3% above the trend GDP growth)? Discounting the value of this low payoff by the interest rates that would have prevailed with this supply side shock (*i.e.* pure time preference *plus* trend growth *plus* 1.5%, the boost to world GDP from a 3% rise in US GDP) gives a comparable "bad luck" figure of just under half of the US GDP. Subtracting this from the *ex ante* valuation gives a market fall of US dollar 3.2 trillion, about a third of the US GDP.

The fall will be larger if it follows a bout of "irrational exuberance". If exuberance raises the expected value of the "New Economy" shock by a fifth, from 5% to 6% of GDP, *ex ante* valuations rise close to 100% of GDP, and the corresponding fall becomes US dollar 4.7 trillion, somewhat less than half of the US GDP (see the middle panel of Table 5). *Ex ante* market values rise yet further if there is a perceived downside assurance "guaranteeing" that bad luck can only take the supply side down by half the standard deviation. With a perceived floor of 3.5%, for example, market values rise to US dollar 10 trillion, *i.e.* the value of one year's US national output. If the supply side nevertheless comes in at 3%, lower than the putative floor, the market fall reaches about US dollar 5 trillion. This loss is less than the figure given by Greenspan for the whole market, but it closely matches the fall in the market capitalisation of the Nasdaq, *i.e.* the losses from the "New Economy" boom.[20]

To sum up, over 60% of the market fall shown in the table is due to losses suffered from investment under rational expectations (bad luck), about 30% due to irrational exuberance (defined as expectations of the US growth rate in the good state exceeding 7%) and less than 10% to meta moral hazard. These fractions largely reflect the parameters chosen to characterise the various scenarios, and can be changed accordingly. There may be interactions between meta moral hazard and the amount of irrational exuberance, for example, as the distinction between these two cases is purely arbitrary in the model calibrations. With the value of hindsight one might wish to include the impact of false accounting by auditors subject to severe conflicts of interest. If audited figures were deliberately biased in an optimistic direction, one might want to reclassify some of what we call bad luck as irrational exuberance due over-optimism both by investors and their accountants.

Finally, in a model of two symmetric blocs half of the total loss, some US dollar 2.7 trillion, would be taken by foreign shareholders outside the US. This figure is, of course, purely indicative but it serves to illustrate the potential for international business cycle spillovers via the wealth channel. Moreover, while the rest of the world most likely suffered substantial losses from

[20] Of course, a "disappointing" low state growth realisation of 3% above trend GDP growth, that follows from our +/-2% distribution around the 5% expected growth rate in excess of trend growth that was used by BMW, may sound optimistic in the case of the downside risks that in fact materialised following the period of significant over-investment during the 1990s boom. Therefore, part of the fact that our calibrations provide results that seem slightly less pronounced than the realised outcomes (while still of right order of magnitude) could be due to this "optimistic" view on the downside risk. All in all the results are, of course, only indicative of the true losses.

investments in the US markets the stock market downturn was not limited to the US.[21] Finally, it should not be ignored that despite the losses on global consumption in the bad state, over time the negative welfare effects from international risk-sharing as illustrated in the above calibrations could also have positive implications for the global economy. Having been able to export part of its losses from past over-investment, the US could be in a better position to contribute to global economic recovery in the future.

5. Conclusions

Within economies, financial assets, notably equity and derivatives, spread the effects of asset price losses. With the increase in cross-border financial flows, particularly in equity, such shocks are also being transmitted internationally. This paper offers a framework for analysing the international allocation of risk. We illustrate how international financial flows can become independent of the underlying current account considerations, and how investors expecting rapid future growth in the home economy are able to hedge part of their risk by selling equity shares and buying foreign bonds. We also show that the size of the international risk sharing flows are dependent on assumptions regarding investors' *ex ante* optimism vis-à-vis future economic growth prospects, in line with the "irrational exuberance" argument as was suggested by Shiller (2000) in the context of the US "New Economy" bubble of the 1990s. As the bubble deflates, the calibrations allow us to study the global distribution of the *ex post* losses arising under different scenarios regarding investors' expectations. In particular, we can distinguish between losses that are caused by a poor draw, irrational exuberance and false insurance caused by ill-founded expectations of a safety net provided by activist monetary policy.

A central implication of our work is that an anticipated supply side shock that fails to materialise *ex post* has quite different implications on global wealth positions depending on the assets involved in the *ex ante* capital transfers. Taking as an example the US "New Economy" boom, had the US financed its widening current account deficit with fixed coupon debt US consumers alone would have had to absorb the full force of the market fall after part of the perceived

[21] However, it has been argued that due to the larger market capitalisation of the US stock market the developments there tend to dominate the rest of the world (see Meredith, 2001).

productivity gains of the 1990s started to evaporate in 2000. But because the US external deficit was to a large extent financed through sales of US equity shares, part of the losses generated from stock market correction in the US were distributed abroad. The calibration results suggest that our model is capable of producing wealth losses of the magnitude experienced by the US after the burst of the "New Economy" bubble within a reasonable range of parameter values that are also consistent with previous research. Moreover, and also along the lines with the calibration results, it is possible that the US stock market downturn could have had effects on income and consumption in the rest of the world if disappointed expectations generated imported negative wealth effects.

Our simple model serves to illustrate the dynamic aspects of international financial flows under uncertainty. A more comprehensive study of the implications of international risk sharing, that should also encompass exchange rate considerations, would require an extended framework. As an example, a model that incorporates differentiated traded goods and terms of trade effects, such as de Fiore and Liu (2002), could allow a starting point for a joint treatment of links between the current account and the exchange rate. In addition, the maintained assumption of efficient financial markets could be relaxed. In this context, recent work by Hau and Rey (2001) shows that once the assumption of perfect hedging of financial flows is dropped, risk sharing flows can account for large fluctuations in exchange rates. Incorporating such considerations are obvious candidates for future research.

References

Bailey, A., S. Millard and S. Wells (2001): "Capital Flows and Exchange Rates." *Bank of England Quarterly Bulletin,* Autumn, pp.310-318

Cechetti, S., H. Genberg, J. Lipsky and S. Wadhwani (2000): *Asset Prices and Central Bank Policy,* Centre for Economic Policy Research, London

De Fiore, F. and Z. Liu (2002): "Openness and Equilibrium Determinacy under intererest rate rules" *ECB Working Paper* No. 173

Greenspan, Alan (2001) 'World Finance and Risk Management', Speech at Lancaster House, London

International Monetary Fund (2001): "What is Driving the Weakness of the Euro and the Strength of the Dollar?" In: *IMF World Economic Outlook,* May 2001

Mas-Colell, A., M. D. Whinston and J.R.Green (1995). "*Microeconomic Theory*." Oxford: Oxford University Press

Meredith, G. (2001) "Why Has the Euro Been so Weak?" Mimeo, *IMF Working Paper Series*

Miller, M., P. Weller and L. Zhang (2001): "Moral Hazard and the US Stock Market: the Idea of a Greenspan Put." *CEPR Discussion paper 3041,* November. Forthcoming in the Economic Journal

Obstfeld, M, and Rogoff, K. (1996): *"Foundations of International Macroeconomics".* Cambridge, Mass., MIT Press.

Rogoff, K. (1999): International Institutions for Reducing Global Financial Instability", *Journal of Economic Perspectives,* Vol 13, No. 4.

SIPC (2000) "Key Investor Survival Quiz Findings" *Securities Investor Protection Corporation Publications*

Shiller, R. (2000): *"Irrational Exuberance"* Princeton, N.J.: Princeton University Press

Tille, C., Stoffels, N. and Gorbachev, O. (2001): "To What Extent Does Productivity Drive the Dollar?" *Federal Reserve Bank of New York Current Issues in Economics and Finance,* Vol. 7, No 8, August

European Central Bank working paper series

For a complete list of Working Papers published by the ECB, please visit the ECB's website (http://www.ecb.int).

113 "Financial frictions and the monetary transmission mechanism: theory, evidence and policy implications" by C. Bean, J. Larsen and K. Nikolov, January 2002.

114 "Monetary transmission in the euro area: where do we stand?" by I. Angeloni, A. Kashyap, B. Mojon, D. Terlizzese, January 2002.

115 "Monetary policy rules, macroeconomic stability and inflation: a view from the trenches" by A. Orphanides, December 2001.

116 "Rent indices for housing in West Germany 1985 to 1998" by J. Hoffmann and C. Kurz., January 2002.

117 "Hedonic house prices without characteristics: the case of new multiunit housing" by O. Bover and P. Velilla, January 2002.

118 "Durable goods, price indexes and quality change: an application to automobile prices in Italy, 1988-98" by G. M. Tomat, January 2002.

119 "Monetary policy and the stock market in the euro area" by N. Cassola and C. Morana, January 2002.

120 "Learning stability in economics with heterogeneous agents" by S. Honkapohja and K. Mitra, January 2002.

121 "Natural rate doubts" by A. Beyer and R. E. A. Farmer, February 2002.

122 "New technologies and productivity growth in the euro area" by F. Vijselaar and R. Albers, February 2002.

123 "Analysing and combining multiple credit assessments of financial institutions" by E. Tabakis and A. Vinci, February 2002.

124 "Monetary policy, expectations and commitment" by G. W. Evans and S. Honkapohja, February 2002.

125 "Duration, volume and volatility impact of trades" by S. Manganelli, February 2002.

126 "Optimal contracts in a dynamic costly state verification model" by C. Monnet and E. Quintin, February 2002.

127 "Performance of monetary policy with internal central bank forecasting" by S. Honkapohja and K. Mitra, February 2002.

128 "Openness, imperfect exchange rate pass-through and monetary policy" by F. Smets and R. Wouters, February 2002.

129 "Non-standard central bank loss functions, skewed risks, and certainty equivalence" by A. al-Nowaihi and L. Stracca, March 2002.

130 "Harmonized indexes of consumer prices: their conceptual foundations" by E. Diewert, March 2002.

131 "Measurement bias in the HICP: what do we know, and what do we need to know?" by M. A. Wynne and D. Rodríguez-Palenzuela, March 2002.

132 "Inflation dynamics and dual inflation in accession countries: a "new Keynesian" perspective" by O. Arratibel, D. Rodríguez-Palenzuela and C. Thimann, March 2002.

133 "Can confidence indicators be useful to predict short-term real GDP growth?" by A. Mourougane and M. Roma, March 2002.

134 "The cost of private transportation in the Netherlands, 1992-99" by B. Bode and J. Van Dalen, March 2002.

135 "The optimal mix of taxes on money, consumption and income" by F. De Fiore and P. Teles, April 2002.

136 "Retail bank interest rate pass-through: the new evidence at the euro area level" by G. de Bondt, April 2002.

137 "Equilibrium bidding in the eurosystem's open market operations" by U. Bindseil, April 2002.

138 "New" views on the optimum currency area theory: what is EMU telling us?" by F. P. Mongelli, April 2002.

139 "On currency crises and contagion" by M. Fratzscher, April 2002.

140 "Price setting and the steady-state effects of inflation" by M. Casares, May 2002.

141 "Asset prices and fiscal balances" by F. Eschenbach and L. Schuknecht, May 2002.

142 "Modelling the daily banknotes in circulation in the context of the liquidity management of the European Central Bank", by A. Cabrero, G. Camba-Mendez, A. Hirsch and F. Nieto, May 2002.

143 "A non-parametric method for valuing new goods", by I. Crawford, May 2002.

144 "A failure in the measurement of inflation: results from a hedonic and matched experiment using scanner data", by M. Silver and S. Heravi, May 2002.

145 "Towards a new early warning system of financial crises", by M. Fratzscher and M. Bussiere, May 2002.

146 "Competition and stability – what's special about banking?", by E. Carletti and P. Hartmann, May 2002.

147 "Time-to-build approach in a sticky price, sticky wage optimising monetary model, by M. Casares, May 2002.

148 "The functional form of yield curves" by V. Brousseau, May 2002.

149 "The Spanish block of the ESCB multi-country model" by A. Estrada and A. Willman, May 2002.

150 "Equity and bond market signals as leading indicators of bank fragility" by R. Gropp, J. Vesala and G. Vulpes, June 2002.

151 "G7 inflation forecasts" by F. Canova, June 2002.

152 "Short-term monitoring of fiscal policy discipline" by G. Camba-Mendez and A. Lamo, June 2002.

153 "Euro area production function and potential output: a supply side system approach" by A. Willman, June 2002.

154 "The euro bloc, the dollar bloc and the yen bloc: how much monetary policy independence can exchange rate flexibility buy in an interdependent world?" by M. Fratzscher, June 2002.

155 "Youth unemployment in the OECD: demographic shifts, labour market institutions, and macroeconomic shocks" by J. F. Jimeno and D. Rodriguez-Palenzuela, June 2002.

156 "Identifying endogenous fiscal policy rules for macroeconomic models" by J. J. Perez, and P. Hiebert, July 2002.

157 "Bidding and performance in repo auctions: evidence from ECB open market operations" by K. G. Nyborg, U. Bindseil and I. A. Strebulaev, July 2002.

158 "Quantifying Embodied Technological Change" by P. Sakellaris and D. J. Wilson, July 2002.

159 "Optimal public money" by C. Monnet, July 2002.

160 "Model uncertainty and the equilibrium value of the real effective euro exchange rate" by C. Detken, A. Dieppe, J. Henry, C. Marin and F. Smets, July 2002.

161 "The optimal allocation of risks under prospect theory" by L. Stracca, July 2002.

162 "Public debt asymmetries: the effect on taxes and spending in the European Union" by S. Krogstrup, August 2002.

163 "The rationality of consumers' inflation expectations: survey-based evidence for the euro area" by M. Forsells and G. Kenny, August 2002.

164 "Euro area corporate debt securities market: first empirical evidence" by G. de Bondt, August 2002.

165 "The industry effects of monetary policy in the euro area" by G. Peersman and F. Smets, August 2002.

166 "Monetary and fiscal policy interactions in a micro-founded model of a monetary union" by R. M.W.J. Beetsma and H. Jensen, August 2002.

167 "Identifying the effects of monetary policy shocks on exchange rates using high frequency data" by J. Faust, J.H. Rogers, E. Swanson and J.H. Wright, August 2002.

168 "Estimating the effects of fiscal policy in OECD countries" by R. Perotti, August 2002.

169 "Modelling model uncertainty" by A. Onatski and N. Williams, August 2002.

170 "What measure of inflation should a central bank target?" by G. Mankiw and R. Reis, August 2002.

171 "An estimated stochastic dynamic general equilibrium model of the euro area" by F. Smets and R. Wouters, August 2002.

172 "Constructing quality-adjusted price indices: a comparison of hedonic and discrete choice models" by N. Jonker, September 2002.

173 "Openness and equilibrium determinacy under interest rate rules" by F. de Fiore and Z. Liu, September 2002.

174 "International monetary policy co-ordination and financial market integration" by A. Sutherland, September 2002.

175 "Monetary policy and the financial accelerator in a monetary union" by S. Gilchrist, J.O. Hairault and H. Kempf, September 2002.

176 "Macroeconomics of international price discrimination" by G. Corsetti and L. Dedola, September 2002.

177 "A theory of the currency denomination of international trade" by P. Bacchetta and E. van Wincoop, September 2002.

178 "Inflation persistence and optimal monetary policy in the euro area" by P. Benigno and J.D. López-Salido, September 2002.

179 "Optimal monetary policy with durable and non-durable goods" by C.J. Erceg and A.T. Levin, September 2002.

180 "Regional inflation in a currency union: fiscal policy versus fundamentals" by M. Duarte and A.L. Wolman, September 2002.

181 "Inflation dynamics and international linkages: a model of the United States, the euro area and Japan" by G. Coenen and V. Wieland, September 2002.

182 "The information content of real-time output gap estimates: an application to the euro area" by G. Rünstler, September 2002.

183 "Monetary policy in a world with different financial systems" by E. Faia, October 2002.

184 "Efficient pricing of large-value interbank payment systems" by C. Holthausen and J.-C. Rochet, October 2002.

185 "European integration: what lessons for other regions? The case of Latin America" by E. Dorrucci, S. Firpo, M. Fratzscher and F. P. Mongelli, October 2002.

186 "Using money market rates to assess the alternatives of fixed versus variable rate tenders: the lesson from 1989-98 data for Germany" by M. Manna, October 2002.

187 "A fiscal theory of sovereign risk" by M. Uribe, October 2002.

188 "Should central banks really be flexible?" by H. P. Grüner, October 2002.

189 "Debt reduction and automatic stabilisation" by P. Hiebert, J. J. Pérez and M. Rostagno, October 2002.

190 "Monetary policy and the zero bound to interest rates: a review" by T. Yates, October 2002.

191 "The fiscal costs of financial instability revisited" by L. Schuknecht and F. Eschenbach, November 2002.

192 "Is the European Central Bank (and the United States Federal Reserve) predictable?" by G. Perez-Quiros and J. Sicilia, November 2002.

193 "Sustainability of public finances and automatic stabilisation under a rule of budgetary discipline" by J. Marín, November 2002.

194 "Sensitivity analysis of volatility: a new tool for risk management" by S. Manganelli, V. Ceci and W. Vecchiato, November 2002.

195 "In-sample or out-of-sample tests of predictability: which one should we use?" by A. Inoue and L. Kilian, November 2002.

196 "Bootstrapping autoregressions with conditional heteroskedasticity of unknown form" by S. Gonçalves and L. Kilian, November 2002.

197 "A model of the Eurosystem's operational framework for monetary policy implementation" by C. Ewerhart, November 2002.

198 "Extracting risk-neutral probability densities by fitting implied volatility smiles: some methodological points and an application to the 3M EURIBOR futures option prices" by A. B. Andersen and T. Wagener, December 2002.

199 "Time variation in the tail behaviour of bund futures returns" by T. Werner and C. Upper, December 2002.

200 "Interdependence between the euro area and the United States: what role for EMU?" by M. Ehrmann and M. Fratzscher, December 2002.

201 "Euro area inflation persistence" by N. Batini, December 2002.

202 "Aggregate loans to the euro area private sector" by A. Calza, M. Manrique and J. Sousa, January 2003.

203 "Myopic loss aversion, disappointment aversion and the equity premium puzzle" by D. Fielding and L. Stracca, January 2003.

204 "Asymmetric dynamics in the correlations of global equity and bond returns" by L. Cappiello, R.F. Engle and K. Sheppard, January 2003.

205 "Real exchange rate in an inter-temporal n-country-model with incomplete markets" by B. Mercereau, January 2003.

206 "Empirical estimates of reaction functions for the euro area" by D. Gerdesmeier and B. Roffia, January 2003.

207 "A comprehensive model on the euro overnight rate" by F. R. Würtz, January 2003.

208 "Do demographic changes affect risk premiums? Evidence from international data" by A. Ang and A. Maddaloni, January 2003.

209 "A framework for collateral risk control determination" by D. Cossin, Z. Huang, D. Aunon-Nerin and F. González, January 2003.

210 "Anticipated Ramsey reforms and the uniform taxation principle: the role of international financial markets" by S. Schmitt-Grohé and M. Uribe, January 2003.

211 "Self-control and savings" by P. Michel and J.P. Vidal, January 2003.

212 "Modelling the implied probability of stock market movements" by E. Glatzer and M. Scheicher, January 2003.

213 "Aggregation and euro area Phillips curves" by S. Fabiani and J. Morgan, February 2003.

214 "On the selection of forecasting models" by A. Inoue and L. Kilian, February 2003.

215 "Budget institutions and fiscal performance in Central and Eastern European countries" by H. Gleich, February 2003.

216 "The admission of accession countries to an enlarged monetary union: a tentative assessment" by M. Ca'Zorzi and R. A. De Santis, February 2003.

217 "The role of product market regulations in the process of structural change" by J. Messina, March 2003.

218 "The zero-interest-rate bound and the role of the exchange rate for monetary policy in Japan" by G. Coenen and V. Wieland, March 2003.

219 "Extra-euro area manufacturing import prices and exchange rate pass-through" by B. Anderton, March 2003.

220 "The allocation of competencies in an international union: a positive analysis" by M. Ruta, April 2003.

221 "Estimating risk premia in money market rates" by A. Durré, S. Evjen and R. Pilegaard, April 2003.

222 "Inflation dynamics and subjective expectations in the United States" by K. Adam and M. Padula, April 2003.

223 "Optimal monetary policy with imperfect common knowledge" by K. Adam, April 2003.

224 "The rise of the yen vis-à-vis the ("synthetic") euro: is it supported by economic fundamentals?" by C. Osbat, R. Rüffer and B. Schnatz, April 2003.

225 "Productivity and the ("synthetic") euro-dollar exchange rate" by C. Osbat, F. Vijselaar and B. Schnatz, April 2003.

226 "The central banker as a risk manager: quantifying and forecasting inflation risks" by L. Kilian and S. Manganelli, April 2003.

227 "Monetary policy in a low pass-through environment" by T. Monacelli, April 2003.

228 "Monetary policy shocks – a nonfundamental look at the data" by M. Klaeffing, May 2003.

229 "How does the ECB target inflation?" by P. Surico, May 2003.

230 "The euro area financial system: structure, integration and policy initiatives" by P. Hartmann, A. Maddaloni and S. Manganelli, May 2003.

231 "Price stability and monetary policy effectiveness when nominal interest rates are bounded at zero" by G. Coenen, A. Orphanides and V. Wieland, May 2003.

232 "Describing the Fed's conduct with Taylor rules: is interest rate smoothing important?" by E. Castelnuovo, May 2003.

233 "The natural real rate of interest in the euro area" by N. Giammarioli and N. Valla, May 2003.

234 "Unemployment, hysteresis and transition" by M. León-Ledesma and P. McAdam, May 2003.

235 "Volatility of interest rates in the euro area: evidence from high frequency data" by N. Cassola and C. Morana, June 2003.

236 "Swiss monetary targeting 1974-1996: the role of internal policy analysis" by G. Rich, June 2003.

237 "Growth expectations, capital flows and international risk sharing" by O. Castrén, M. Miller and R. Stiegert, June 2003.