

# World Finance and the US “New Economy”: welfare efficiency and moral hazard<sup>1</sup>

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## *Abstract*

Promises of a ‘New Economy’ in the US attracted substantial equity inflows in the late 1990s -- more than enough to finance the current account US deficit. Since their peak in 2002, however, US stocks have fallen in value by some 8 trillion dollars. To assess welfare effects of global financial markets in this context, we use an analytically tractable (two-country, two-period, two-state) model of the global economy which allows the country experiencing the New Economy “shock” to consume more against expected future output and to spread risk by selling shares. As distorted corporate incentives can cause serious asset overvaluation, however, a “moral hazard bubble” is also incorporated. Relative to autarky, global financial markets do offer welfare gains. But these are small: a lot smaller than the wealth transfer to the US that can arise from selling shares at inflated prices! Parameter variations suggest that this conclusion is quite robust.

A calibrated exercise shows how capital inflows to the US can double the consumption-smoothing deficit on the current account; and how market losses --- due to ‘misfortune’ or moral hazard --- have global effects on consumption when the bubble bursts. The analysis complements recent econometric studies of the transmission mechanism which find that financial factors are needed to explain why the European economy was so strongly affected by the US downturn starting in 2002.

*JEL Classification:* F41, F32, G15

*Key words:* Capital flows, moral hazard, international transmission of shocks.

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# 1. Introduction

The role of risk-sharing role in the financial system was a central element in Alan Greenspan's October 2002 talk on "World Finance and Risk Management". In addressing the UK Treasury, the Chairman of the Federal Reserve highlighted the way financial assets can smooth consumption not just over time but also across different states of nature. To illustrate the importance of risk spreading, he cited the steadiness of the US economy in face of "the draining impact of a loss of 8 trillion dollars of stock market wealth" and of other adverse shocks throughout 2001-02. As the US productivity boom in the 1990s was to a large extent equity-financed, this meant that the decline in asset valuations was largely absorbed by shareholders, avoiding the concentration of risks in the corporate sector and banking associated with highly-leveraged financing. But the international dimensions of risk-sharing and the 'moral hazard' aspects of asset price fluctuations were not stressed by the Fed Chairman. They are the focus of this paper which looks at the welfare benefits offered by financial markets for consumption-smoothing and risk-spreading; and the international transfers that may occur when a stock-price bubble driven by distorted incentives finally bursts.

The principal evidence of distorted incentives in the asset price boom of the 1990s in the US has subsequently emerged in the bankruptcy courts, where corporate officials have been indicted for misappropriation of funds and fraud. According to one observer, "stock options distorted managerial incentives, [and] consulting distorted auditors incentives"; and the case of Enron, for example, has shown that "shareholders didn't have the information with which to judge what was going on, and there were incentives not to provide that information but to provide distorted information" Stiglitz (2003, pp. 139 and 248). Much of the blame for these corporate excesses is attributed by Stiglitz to the zeal for deregulation that began with President Reagan<sup>2</sup>. This might seem an argument of convenience by one who was Chairman of the CEA under Clinton, whose Presidency covered many of the boom years: but there has in fact been a substantial shift to re-regulation under President Bush, particularly in the form of the Sarbanes-Oxley Act which requires CEOs and CFOs to certify financial reports, with criminal penalties for miscertification. Academic evidence of distorted incentives is summarised in a recent survey of theory and evidence relating to corporate 'excesses' and financial market dynamics circulated by the ECB. Stock

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<sup>2</sup> He also criticises the Chairman of the Fed for failing to follow up his 'irrational exuberance' speech in 1996 by acting on interest rates or margin requirements, Stiglitz (2003, chapter 3 ).

options, while designed to align the interest of managers and shareholders, have, in the view of the authors, “turned out to have other effects: managers had an interest in driving up the stock price of their firm to realise their gains, exercising their options and cashing in upon leaving the company. Furthermore, particularly in the US, the use of stock options helped to distort published earnings” (Maddaloni and Pain, 2004, p13). As to whether the financial market bubble was, at least in part, inflated by biased investment advice given by stock market analysts and broker-dealers, the authors conclude: “although the more innocent explanation of ‘irrational exuberance’ [...] cannot be ruled out, [the] history of biased earning forecasts is perhaps more consistent with the influence of the *conflict of interest* embedded in combining investment advice with securities underwriting and brokerage activities”<sup>3</sup> (Maddaloni and Pain, 2004, p 4-5).

What of the international implications? Spurred on by the “New Economy” productivity boom, the United States ran a significant current account deficit the second half of the 1990s (see Table 1)<sup>4</sup>; and it also acted as a magnet for global capital flows. In an inter-temporal analysis, Bailey, Millard and Wells (henceforth BMW, 2001) argued that this current account deficit was driven by consumption rising in anticipation of future income gains (the anticipated productivity shock); and the capital inflows served to finance this consumption smoothing exercise<sup>5</sup>.

Table 1: The ‘over-financing’ of the US current account

US \$ 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
Total Capital inflows	216	172	81	259	411	340	321

\*Including foreign official investment in US Government Securities

<sup>3</sup> They cite Chan et al (2003) who interpret the US evidence that the proportion of positive ‘earnings surprises’ persistently outweighs that of negative surprises as consistent with analysts massaging their forecasts to engineer good news.

<sup>4</sup> 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.

<sup>5</sup> They also 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 lead to a real appreciation of the US dollar via the Balassa-Samuelson effect.

But the financing side of the US Balance of Payments (shown in second and third rows of the Table 1) suggest there was more to the capital flows than this. In the late 1990s net inflows to the US in the form of foreign direct and total portfolio investment exceeded the underlying current account positions in several years, thus generating a surplus in the US basic balance.<sup>6</sup> This meant that some of the inflows could finance US purchases of foreign *non-equity* assets. The breakdown of the portfolio flows, moreover, reveals that equity inflows to the United States increased strongly up to 2000, when the “New Economy” boom was touted in the financial press as a historic shift in economic fundamentals; but in 2001-02, amid a global economic slowdown and the bursting of the equity bubble, the composition of the US portfolio inflows changed, with the share of equity flows falling sharply relative to flows in bonds.

While the dynamic theory of the balance of payments under certainty focuses on the role of financial markets in smoothing consumption, risk-sharing provides an additional motive for capital flows in a stochastic environment, Obstfeld and Rogoff (1996, p)<sup>7</sup>: and equity investment in new technology is inherently risky. To characterise the two motives for US capital inflows analytically, we use a stylised two-country, two-period general equilibrium framework with an anticipated, stochastic productivity boom in one country (the US). In the simulations that follow the model specification, as in Debreu’s original formulation<sup>8</sup>, the distribution perceived by investors can differ from the true distribution: here this discrepancy is attributed to “corporate moral hazard” and “meta moral hazard” (where the former is designed to capture the false accounting, etc. due to distorted incentives and the latter to capture the idea of a ‘Greenspan put’<sup>9</sup>).

We note first that efficient risk sharing implies that the consumers in the faster- growing region sell risky equity shares and buy risk-free fixed income assets that provide consumption in all states of the world. Second that the pattern of share-holding ex ante has clear implications for the ex post distribution of losses. (Where the ending of the asset price boom is characterised by a realisation below the true expected value -- and a fortiori below the expected value after distortions due to

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<sup>6</sup> The basic balance is here defined as the sum of the current account, direct and portfolio investment. In economic terms, a surplus means that some of the inflows are financing US purchases of foreign *non-equity* assets.

<sup>7</sup> In their classic studies of general equilibrium, Arrow and Debreu include a complete set of contracts running through time and across all states.

<sup>8</sup> In the “Theory of value”, Debreu (1959) solves for general equilibrium using subjective, not objective probabilities.

<sup>9</sup> Miller et al.(2002)

moral hazard – there are significant ex post wealth transfers across the world very different from those associated with debt finance.) Expected welfare calculations show that, in the absence of distortions, the gains from trade in global financial markets are positive, but very small: in terms of consumption flows, they are worth only about one hundredth of one percent of GDP to each country -- a finding which is robust to parameter variations.

But the implications of asset price overvaluation - stemming, perhaps, from distorted incentives in the corporate sector - is more striking. Since these involve transfers from investors worldwide to US producers, the US enjoys a transfer which rises in proportion to the distortion in asset prices. (The losses to foreign investors are of the similar magnitude.) In the basic case of corporate moral hazard described below the US enjoys an international a transfer of almost half of one percent of GDP. Taking account of home bias in investors' portfolios, the ratio of this unintended transfer to the efficiency gains is overstated. But even if the transfer were scaled down by a factor of ten, transfer losses would still dominate efficiency gains for the rest of the world.

Finally we suggest that the analysis complements recent econometric studies of the transmission mechanism which find that financial factors are needed to explain “why the European economy was strongly affected by the US downturn in the US” (Artis et al, 2003).

The paper proceeds as follows. In section 2 we introduce the model for consumption and investment, with optimal portfolio allocation between equity and debt. In section 3 we first derive the key welfare results setting  $\sigma$  and  $\rho$  to unity (i.e. for the log utility model in section 2.4); then we check on robustness. 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 Financial Markets: a global model

To formalise the arguments we specify a two-period dynamic stochastic general equilibrium model, in tradition of Weil (1990) and Obstfeld and Rogoff (1996), that allows for separate treatment of parameters for intertemporal substitution and cross-state substitution (risk aversion). By deriving the general equilibrium consumption allocation when the product of elasticities of

intertemporal substitution and cross-state substitution can differ from 1, we extend the results of Obstfeld and Rogoff (1996). In this setup, we obtain equilibrium consumption allocation, asset holding, and current account positions with and without the presence of moral hazard; we then compare the welfare changes to the welfare gain by completing the asset markets. To better understand the results, we also present the case where inter-state and intertemporal preferences are both given by logarithmic utilities.

Consider an economy with two-countries (home and foreign) who exchange and consume one tradable good. The economy exists for two periods. There is no uncertainty in the first period, the endowments for both home and foreign countries are given by  $Y_1 = Y_1^*$ , where  $*$  denotes foreign variables. In the second period, both countries enjoy a non-stochastic growth in output with a rate at  $g$ . The home country in addition experiences the “New Economy”, a positive supply shock with a higher growth rate of  $h$  and lower growth rate of  $l$ . Indexing these states by  $s$ , the home country’s date 2 endowments are given respectively  $Y_2(1) = Y_1(1 + g + h)$  and  $Y_2(2) = Y_1(1 + g + l)$ , with their ex ante probability of  $0 < \pi(s) < 1$  and  $\sum_s \pi(s) = 1$  (later in this section, we will use  $\pi(1) = \pi$  and  $\pi(2) = 1 - \pi$ ). The date 2 endowments for the foreign country are given by  $Y_2^*(1) = Y_2^*(2) = Y_1^*(1 + g)$ .

Representative consumers in both countries share identical preferences. Home country’s lifetime utility is specified by

$$U(C_1, \Omega) = u(C_1) + \beta u(\Omega) \quad (2.1)$$

where  $\beta$  is the time preferences. The date 2 consumption index  $\Omega$  is defined as

$$\lambda(\Omega) = \sum_s \pi(s) \lambda[C_2(s)] \quad (2.2)$$

where  $C_2(s)$  indicates date 2 state-contingent consumption with cross-state utility given by CRRA family

$$\lambda(C) = C^{1-\rho} / (1-\rho), \quad \rho > 0 \quad (2.3)$$

where  $\rho$  is the risk aversion. The intertemporal utility is specified as

$$u(C) = C^{1-1/\sigma} / (1-1/\sigma), \quad \sigma > 0 \quad (2.4)$$

with  $\sigma$  representing elasticity of intertemporal substitution.

Let  $Z_2$  denote total spending on date 2 goods (measured in certainty-equivalent period 2 consumption terms) and  $P$  denotes the date 2 consumption based price index. Given (2.2), we have

$$\Omega \equiv \lambda^{-1} \left\{ \sum_s \pi(s) \lambda[C_2(s)] \right\} = Z_2 / P. \quad (2.5)$$

Assume complete asset markets with 2 Arrow-Debreu securities. Their prices are given by  $p(s) > 0$  ( $s = 1, 2$ ) measured in date 2 sure consumption goods. The no-arbitrage requires

$$\sum_s p(s) = 1 \quad (2.6)$$

The budget constraint of the home country is given by

$$C_1 + \frac{Z_2}{1+r} = W_1 \equiv Y_1 + \frac{\sum_s p(s) Y_2(s)}{1+r} \quad (2.7)$$

where  $W_1$  is home country's life-time wealth and  $r$  is the real interest rate.

## 2.1 Partial equilibrium consumption allocation

The partial equilibrium optimal consumption allocation for any  $\rho$  and  $\sigma$  are solved in Obstfeld and Rogoff (1996, chapter 4) in a two-stage fashion. In what follows, we report their results.

The date 2 state-contingent consumption is obtained by maximising date 2 expected utility subject to given expenditure  $Z_2$ . This gives state-contingent consumption as

$$C_2(s) = \frac{[\pi(s) / p(s)]^{1/\rho}}{\sum_{s'} p(s') [\pi(s') / p(s')]^{1/\rho}} Z_2 \quad (2.8)$$

The date 2 consumption index

$$\Omega = \left\{ \sum_s p(s) [\pi(s) / p(s)]^{1/\rho} \right\}^{1/(1-\rho)} Z_2 \quad (2.9)$$

The date 2 price for consumption index

$$P = \left\{ \sum_s p(s) [\pi(s) / p(s)]^{1/\rho} \right\}^{-\rho/(1-\rho)}. \quad (2.10)$$

The optimal intertemporal allocation is obtained by maximising the lifetime utility subject to the budget constraint (2.7). The resulting date 1 consumption and date 2 expenditure are given by

$$C_1 = \frac{W_1}{1 + \beta[\beta(1+r)/P]^{\sigma-1}} \quad (2.11)$$

and

$$Z_2 = \frac{(1+r)W_1}{1 + \beta^{-1}[\beta(1+r)/P]^{1-\sigma}}. \quad (2.12)$$

## 2.2. Prices and Consumption in General Equilibrium

Here, we extend Obstfeld and Rogoff (1996) by deriving equilibrium prices and allocation when  $\rho\sigma$  may be different from 1. (In the baseline case to be presented in the following sections, however, we assume  $\rho = \sigma = 1$ .) We then vary  $\rho$  and  $\sigma$  to check the robustness of our baseline results.

Denote the world endowments across time and states by

$$Y_1 + Y_1^* = Y_1^W \quad (2.13)$$

$$Y_2(s) + Y_2^*(s) = Y_2^W(s), \quad s = 1, 2. \quad (2.14)$$

The market clearing requires

$$C_1 + C_1^* = Y_1^W \quad (2.15)$$

$$C_2(s) + C_2^*(s) = Y_2^W(s), \quad s = 1, 2. \quad (2.16)$$

To simplify notations, we denote date 2 world consumption index by

$$\Omega^W = \left\{ \sum_s \pi(s) [Y_2^W(s)]^{1-\rho} \right\}^{1/(1-\rho)} \quad (2.17)$$

In what follows, we first derive the equilibrium prices and then their associated consumption allocation.

**Proposition 1:** Given identical preferences for the home and foreign countries. The equilibrium Arrow-Debreu prices and real interest rate are expressed respectively by

$$p(s) = \frac{\pi(s) [Y_2^W(s)]^{-\rho}}{\sum_{s'} \pi(s') [Y_2^W(s')]^{-\rho}} \quad (2.18)$$

and



$$\beta(1+r) = \frac{[Y_1^W / \Omega^W]^{-1/\sigma}}{\sum_{s'} \pi(s') [Y_2^W(s') / \Omega^W]^{-\rho}} \quad (2.19)$$

The date 2 price for consumption index is

$$P = \frac{1}{\sum_{s'} \pi(s') [Y_2^W(s') / \Omega^W]^{-\rho}} \quad (2.20)$$

Proof: See Appendix 1.

**Proposition 2:** The optimal consumptions across time and states for both home and foreign countries are a constant fraction of the corresponding world endowments. Let the fraction for the home country be  $\mu$ , then

$$\mu = \frac{Y_1 [Y_1^W / \Omega^W]^{-1/\sigma} + \beta \sum_{s'} \pi(s') [Y_2^W(s') / \Omega^W]^{-\rho} Y_2(s)}{Y_1^W [Y_1^W / \Omega^W]^{-1/\sigma} + \beta \Omega^W} \quad (2.21)$$

The constant fraction for foreign country is just  $1 - \mu$ .

Proof: see Appendix 1.

Despite the assumption that the future output shock is expected to take place in the home country, however, the equilibrium consumption depends on global output uncertainty. This is shown clearly in (2.18) that Arrow-Debreu prices are only affected by the global output fluctuation. Equation (2.19) shows that a higher expected date 2 world output lowers the expected date 2 marginal utility (after scaling by  $\Omega^W$ ) and therefore raises the world interest rate.

If there is no “New Economy” in the home country (so both countries will have the same growth rates in date 2 output), the equilibrium is simply that both countries consume their respective endowments. When the home country experiences the “New Economy” in period 2, in the first period it would prefer to consume in excess of its income endowment, thus borrowing from the foreign country to cover the corresponding current account deficit. In the next section, we look at home country’s current account positions and its asset holding in equilibrium. Before proceeding we first give some welfare measure for the equilibrium consumption allocation.

**Proposition 3:** The lifetime utility for the home country can be expressed as

$$U(C_1, \Omega) = \mu^{1-1/\sigma} U(Y_1^W, \Omega^W). \quad (2.22)$$

Proof: see Appendix 1.

### 2.3 International transmission of shocks

In this part, we first derive the current account position for the home country and its asset holdings in equilibrium. We then compare home country's welfare measures under autarky, complete asset markets and moral hazard.

Given the equilibrium consumption allocation outlined above, one can easily obtain the home country's current account position. Specifically,

$$CA = C_1 - Y_1 = \mu Y_1^W - Y_1. \quad (2.23)$$

Assume there are two assets traded in the market: one is the stock which is a claim on date 2 home output, the other is a riskless bond which has the return the same as the real interest rate.<sup>10</sup> Given there are only 2 states of nature in period 2, these two assets will complete the market. Let  $S$  denote share of stock held by the home country and  $b$  the level of its bond holding. Period 2 budget constraints can be written as

$$C_2(s) = Y_2(s) - (1 - S)Y_2(s) + b(1 + r) = SY_2(s) + b(1 + r). \quad (2.24)$$

Note that from (2.21),  $C_2(s) = \mu Y_2^W(s)$ , so (2.24) specifies two simultaneous equations for  $S$  and  $b$ . Solving them yields

$$S = \frac{\mu[Y_2^W(1) - Y_2^W(2)]}{Y_2(1) - Y_2(2)} \quad (2.25)$$

$$b = \frac{\mu[Y_2^W(2)Y_2(1) - Y_2^W(1)Y_2(2)]}{(1 + r)[Y_2(1) - Y_2(2)]}. \quad (2.26)$$

For the equilibrium consumption given in section 2.2, what will be the utility gain for the home country when markets are complete? Under autarky, the home country simply consumes its endowments, so date 2 certainty equivalent consumption is

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<sup>10</sup> The riskless bond is similar to a claim on date 2 foreign output.

$$\Omega^A = \left\{ \sum_s \pi(s) [Y_2(s)]^{1-\rho} \right\}^{1/(1-\rho)}$$

with its lifetime utility given by

$$U_A(Y_1, \Omega^A) = u(Y_1) + \beta u(\Omega^A).$$

Given autarky welfare above, we specify the gain from trade as

$$\Delta U_T = U(C_1, \Omega) - U(Y_1, \Omega^A). \quad (2.27)$$

To see how such utility gain can be translated into consumption, we provide the following two measures. First we assume that all the utility gain is accorded to an increase in the first period consumption (the so-called ‘‘Potlatch’’ in the next section), i.e.,

$$U(C_1, \Omega) = U(Y_1 + \Delta C_P, \Omega^A). \quad (2.28)$$

The second is to accord the utility gain to a ‘‘flow’’ of consumption in both periods:

$$U(C_1, \Omega) = U(Y_1 + \Delta C_F, \Omega^A + \Delta C_F). \quad (2.29)$$

These measures will be used in the numerical simulation in section 3.

Let moral hazard be characterised as a case where the distribution perceived by investors can differ from the true distribution, in particular, where the perceived probability,  $\pi_M$ , of higher growth in period 2 is greater than its true probability,  $\pi$ . Denote the consumption allocation under perceived distribution by  $C_i(s; \pi_M)$  and its date 2 certainty equivalent consumption (evaluated under true distribution) by  $\Omega^M = \left\{ \sum_s \pi(s) [C_2(s; \pi_M)]^{1-\rho} \right\}^{1/(1-\rho)}$ . The lifetime utility for such an allocation evaluated under the true distribution is

$$U_M(C_1(\pi_M), \Omega^M) = u(C_1(\pi_M)) + \beta u(\Omega^M)$$

The welfare change due to moral hazard (compare to complete markets case) is simply

$$\Delta U_M = U(C_1(\pi_M), \Omega^M) - U(C_1, \Omega). \quad (2.30)$$

In the simulations in section 3, we also provide consumption measures of this utility change as outlined in (2.28) and (2.29) above.

## 2.4 The logarithmic preferences

To provide some useful illustration, we apply logarithmic preferences (i.e.,  $\rho = \sigma = 1$ ) to the general results derived above. To simplify the presentation, we assume growth rates are small (i.e.,  $g, h, l \ll 1$ ).

Using log specification, (2.17) becomes

$$\Omega^W = \exp\left\{\sum_s \pi(s) \ln[Y_2^W(s)]\right\} = \prod_s [Y_2^W(s)]^{\pi(s)}$$

Using the endowments specified in section 2.1 and the assumption that growth rates are small, we then have

$$\Omega^W = 2Y_1\{1 + g + [\pi h + (1 - \pi)l]/2\}. \quad (2.31)$$

Applying the same procedure to (2.18), (2.19) and (2.21) gives

$$p(1) = \pi[1 - (1 - \pi)(h - l)/2], \quad p(2) = (1 - \pi)[1 + \pi(h - l)/2] \quad (2.32)$$

$$\beta(1 + r) = 1 + g + [\pi h + (1 - \pi)l]/2 \quad (2.33)$$

$$\mu = \frac{1 + \beta + \beta[\pi h + (1 - \pi)l]/2}{2(1 + \beta)} \quad (2.34)$$

It is apparent from (2.32) – (2.34) that an increase in  $\pi$  raises real interest rate and home country's consumption share in the world endowments. It increases the Arrow-Debreu price for the high growth state and reduces the A-D price for the low growth state.

The home country's current account position can now be simplified to

$$CA = \frac{\beta[\pi h + (1 - \pi)l]/2}{2(1 + \beta)} Y_1 \quad (2.35)$$

So an increase in  $\pi$  raises home country's current account deficit.

Approximate (2.28) to the second order yields

$$\Delta C_p = \frac{\beta^2[\pi h + (1 - \pi)l]^2}{4(1 + \beta)} Y_1 \quad (2.36)$$

So the gain from trade measured in period 1 consumption is associated with the variance of period 2 endowment. When the endowment variation is small, the gain from trade will be very small. This result is similar to Lucas (1987) when he looks at the gains from eliminating variation in consumption.

### 3. Welfare Effects

Using this model, we consider US “New Economy” boom of the late 1990s and the early 2000s and analyse its impact on expected welfare both at home (US) and elsewhere. For the baseline, labelled Arrow-Debreu, expected welfare is calculated on the assumption that there is a complete set of market for smoothing consumption over time and for diversifying risk. For this purpose, we use key parameters from the Bank of England study by BMW (2001)<sup>11</sup>. This is followed by a scenario labelled corporate moral hazard (CMH) where investors are deliberately misled about the probability of high payoffs from the “New Economy”.

Details of consumption-smoothing in the US and of global participation in the US market are reserved for the next section. Here we focus on questions of welfare: how much better off would US and foreign consumers be with the “New Economy” shock appropriately financed by the issue of Arrow-Debreu securities? What would the US gain (and foreigners lose) if these securities were sold at prices distorted by the moral hazard? How robust are these calculations to parametric variations?

#### 3.1 The Scenarios

Before presenting the numerical results, we specify the key assumptions involved in the various cases (including a third scenario -- Full Moral Hazard -- where the ‘excess’ probability attached to the high outcome is further increased as Corporate Moral Hazard is amplified by what has been referred to as Meta Moral Hazard, that appears in the checks for robustness that follow).

##### “Base-Line”: Arrow-Debreu

As in 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 of two equi-probable outcomes, a low pay-off  $s^L$  of 3%, and a high pay-off  $s^H$  of 7%. Thus, if the low payoff is observed *ex post*, the market would fall by about 40% --even though the “New Economy” will still take the US economy to 3% above the trend. With correct expectations this downside risk

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<sup>11</sup> So their results can be obtained as a special case of our stochastic framework.

will, however, have been perfectly foreseen and balanced by the upside prospect of the market rising by 40%.

### **“Corporate Moral Hazard”: Stock market bubble**

This scenario tries to capture the outcome when accountants and Chief Executive Officers have private incentives to misreport actual and expected profits; and the normal checks on such misreporting are missing as result of rapid and extensive deregulation. It might seem tempting to model a “moral hazard equilibrium” where these incentives to misreport are checked, not by regulation but by the actions taken by suspicious investors. We do not do this in the paper on the grounds that the degree of misreporting was an unexpected surprise, whose true dimensions are only now apparent to investors, partly as a result of proceedings in the criminal courts. It is worth recalling that, in 1996/7 East Asian economies were being described as dens of “Crony Capitalism” in contrast to the US, whose Anglo-Saxon procedures for accounting and corporate governance were widely commended as a global benchmark. (Later, we assume, for simplicity, that such moral hazard has effectively disappeared with re-regulation e.g. the Oxley-Sarbanes Act.)

How is one to characterise the effects of moral hazard in a general equilibrium model? We do this by simply increasing the *perceived* probability of the high payoff of the “New Economy”; specifically it increases to 0.75, although the true probability still remains 0.5; so the expected supply-side shock rises from 5 to 6 percent of GDP. In this case, if the low state payoff materialises, the market should fall by a half. In the meantime, decisions will have been distorted by excessively bullish expectations.

### **Adding “Meta moral hazard”: the Greenspan put?**

There is some evidence that – at least until late-2000 – investors 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.<sup>12</sup> To capture such optimism, let investors believe that the downside risk is

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<sup>12</sup> 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).

even lower than touted by corporate analysts. Specifically, the “excess probability” attached to the high payoff is increased by a quarter, from 0.25 to 0.3125, so in expectation, the size of the supply side shock rises to 6.25%. With upside prospects boosted by corporate moral hazard as in the previous example, and downside risk artificially reduced by “meta moral hazard”, the market could be set for a rude awakening if the lower payoff turns out to be the true value of the “New Economy”. In this case, if the low state payoff materialises, the market should fall by a little over a half. (Note that the NASDAQ has fallen by about 60%, from around 5000 to below 2000)

### “Autarky”

In this case there is no international finance: in both periods and both states, each country consumes its endowment.

### 3.2. Welfare results

Expected lifetime welfare in the baseline scenario, shown in the middle of Table 2, is to be compared with autarky, shown in top row, where each country consumes its endowment; and with the scenario in which complete markets are tainted by moral hazard, shown in the bottom row. For assessing the welfare changes shown in columns 1 and 4, we present two measures. The first, labelled “Potlatch<sup>13</sup>”, indicates the percentage increase in consumption in the first period which would deliver an equivalent welfare change. Second, roughly half the size, is labelled “Flow”, and indicates the extra consumption flow in both periods which would give the same welfare change.

Table 2. The welfare gains from international finance and moral hazard effects

	Home			Foreign		
	Lifetime Welfare	“Potlatch”	“Flow”	Lifetime Welfare	“Potlatch”	“Flow”
Autarky Equilibrium	9.21141			9.16462		
$\Delta U1$	<b>+0.00018</b>	<b>+0.02</b>	<b>0.01</b>	<b>+0.00019</b>	<b>+0.02</b>	<b>0.01</b>
Arrow-Debreu Equilibrium	9.21159			9.16481		
$\Delta U2$	<b>+0.0045</b>	<b>+0.45</b>	<b>0.23</b>	<b>-0.0047</b>	<b>-0.47</b>	<b>-0.24</b>
Corporate Moral Hazard	9.21611			9.16017		
$\Delta U1+\Delta U2$	<b>+0.0047</b>	<b>+0.47</b>	<b>0.24</b>	<b>-0.0045</b>	<b>-0.45</b>	<b>-0.23</b>

<sup>13</sup> An American word denoting an Indian winter festival, or the gift-giving at that time.

What, then, are the gains achievable by using *global financial markets* to smooth consumption over time and to spread risk of the asymmetric supply side shock internationally? In terms of immediate consumption, the answer for both countries is a “potlatch” of only 1/50 of 1%. Spread over a lifetime, their flow of consumption could increase by half as much, see column 3. So the gains from trade in financial markets are clearly positive, but rather small -- equivalent to a rise in the flow of consumption of only one-hundredth of one percent.

This may be disappointing, but not surprising when one recalls that Lucas(1987) calculated the flow welfare gain to the US from eliminating *all* consumption fluctuations to be less than one-hundredth of one percent of consumption when preferences are logarithmic<sup>14</sup>. Evidently our general equilibrium open economy results are broadly consistent with Lucas’s stylised calculations. (If, in similar fashion, we consider the value of *completely stabilising home consumption* when the supply shock,  $s$ , occurs, the welfare benefit, to a first approximation, would be one-period gain of  $\text{var}(s)/2 = (0.0004)/2 = 0.0002$  and a flow gain of half as much. This is a useful insight, though the fact that it gives precisely the same as gains shown in the table is a coincidence. Presumably the additional benefit of smoothing the *anticipated* supply side shock just offsets the incompleteness of consumption stabilisation in period 2, when *global* risk must still be borne.)

What are the welfare implications of asset price overvaluation stemming, perhaps, from distorted incentives in the corporate sector? Since these involve transfers from investors worldwide to producers in the US, there are winners and losers. On balance, US consumers enjoy potlatch of almost half a percent of GDP, or a permanent increase of about quarter percent --- i.e., more than twenty times the gains from completing financial markets: and the losses to foreign investors are of a similar magnitude. It is not difficult to see why: if corporate moral hazard has lifted the expected size of the New Economy by one percentage point and foreigners acquire almost half of the shares on offer<sup>15</sup>, then they will lose half on one percent in the final *denouement*.

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<sup>14</sup> Updating his calculation to cover the period 1950-1090, Obstfeld and Rogoff(1996 p330) report a figure of  $\rho \cdot \text{Var}(\epsilon)/2 = \rho \cdot 0.0007/2 = \rho \cdot 0.00035$ , where  $\epsilon$  is the annual shock to consumption, and  $\rho$  is the measure of risk aversion: for log utility, this implies a flow gain 0.035 of 1 % of consumption.

<sup>15</sup> See details in next section. Note there is no home bias in the model, and there is perfect symmetry between the two countries.



Summing these changes gives the bottom line: relative to autarky, international financial markets tainted by moral hazard deliver a gain of 0.47 percent of period 1 consumption in the US, but foreigners lose the equivalent of 0.45 percent of period 1 consumption, as the unanticipated transfer offsets their welfare gains from financial markets.<sup>16</sup>

### 3.3 Checking the robustness of the welfare results

How robust are these welfare conclusions? They must depend crucially on the degree of asset mispricing, so we check to see how varying perceived  $\pi$  changes the size of the transfer. We also vary, in turn,  $\rho$  and  $\sigma$ .

#### Varying $\pi$ , the “perceived” probability of the high outcome.

Note from Table 2 that the 22.5 ratio of US moral hazard gains to benefits of consumption stabilisation roughly matches the excess percentage probability attached to the high outcome (75%-50%= 25%): and from the graph below it is clear that this proportionality holds for wide variations in expected  $\pi$ . Hence we conclude that, for our global model with log utility, *the ratio of the potlatch transfer to the US relative to the efficiency gains offered by complete markets approximately matches the excess probability of the high outcome*. So if, for example, “meta moral hazard” was to add a quarter to the asset price overvaluation due to corporate moral hazard (lifting the perceived probability of the high outcome rises to 81.25% and the excess probability to 31.25), then the transfer gains to US would be about 30 times welfare gains of 1/50 of one percent of US consumption, a potlatch of almost 2/3 of a percent of GDP.

As an important qualification, it should be emphasised that this global model is the one of perfect symmetry, with only one good and no “home bias” in portfolios, so foreigners are far more exposed to asset mispricing than is the case in reality. This is discussed further in Section 4.2 below.

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<sup>16</sup> The finding that international transfers can more than offset efficiency gains to opening markets was also a feature of the general equilibrium model of UK entry into the European Community of Miller and Spencer (1977). In practice, however, Mrs Thatcher renegotiated the transfers!

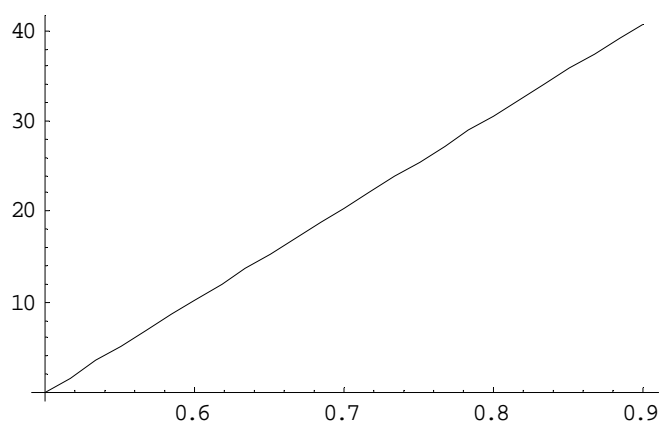


Figure 1. The ratio of transfer gains (potlatch, on vertical axis) and moral hazard distortion ( $\pi - 0.5$ , on horizontal).

### Varying $\rho$ , the coefficient of risk aversion.

Econometric estimates suggest that risk aversion is greater than unity: Corsetti et al. (2003) set it at between 1.5 and 2. With  $\rho = 1.4$ , but all other parameters the same as for Table 2, there is a small decline in lifetime welfare in the US, see below: but the welfare of the foreign country and the effects of market integration and asset mis-pricing are unchanged.

		Home			Foreign	
	Lifetime Welfare	“Potlatch”	“Flow”	Lifetime Welfare	“Potlatch”	“Flow”
Autarky Equilibrium	9.21134			9.16462		
$\Delta U1$	<b>+0.0002</b>	<b>+0.02</b>	<b>0.01</b>	<b>+0.0002</b>	<b>+0.02</b>	<b>0.01</b>
Arrow-Debreu Equilibrium	9.21154			9.16483		
$\Delta U2$	<b>+0.0045</b>	<b>+0.45</b>	<b>0.23</b>	<b>-0.0047</b>	<b>-0.47</b>	<b>-0.24</b>
Corporate Moral Hazard	9.21607			9.16018		
$\Delta U1 + \Delta U2$	<b>+0.0047</b>	<b>+0.47</b>	<b>0.24</b>	<b>-0.0045</b>	<b>-0.45</b>	<b>-0.23</b>

Table 3. Welfare gains from trade and moral hazard effects ( $\rho=1.4$ )

### Varying $\sigma$ sigma, the elasticity of intertemporal substitution

Other modellers typically assume a low degree of substitution over time, Bayoumi et al (2004) use a figure of 0.2 and Juillard et al.(2004) a figure of 0.8. Reducing  $\sigma$  to a half, -- and leaving all other parameters as for Table 2 -- increases the flow benefits of financial integration to each country, and reduces the consumption equivalent of the transfer (so the ratio of the two for the US falls below twenty). As a result net US gains less, and the foreign country loses less than for log utility: but the differences are marginal.

		Home			Foreign	
	Lifetime Welfare*100	“Potlatch”	“Flow”	Lifetime Welfare*100	“Potlatch”	“Annuity”
Autarchy	-1.91729			-1.96191		
$\Delta U1$	<b>+0.0003</b>	<b>+0.03</b>	<b>0.01</b>	<b>+0.0003</b>	<b>+0.03</b>	<b>0.017</b>
Arrow-Debreu	-1.91699			-1.96159		
$\Delta U2$	<b>+0.0042</b>	<b>+0.42</b>	<b>0.23</b>	<b>-0.0047</b>	<b>-0.44</b>	<b>-0.22</b>
Corporate Moral Hazard	-1.91279			-1.966		
$\Delta U1+\Delta U2$	<b>+0.0045</b>	<b>+0.45</b>	<b>0.24</b>	<b>-0.0041</b>	<b>-0.41</b>	<b>-0.21</b>

Table 4. Welfare gains from trade and moral hazard effects (sigma=0.5)

We conclude that the results reported for the log utility case are robust to plausible variations in risk aversion and intertemporal substitution: and the ‘transfer’ effects vary proportionately with the difference between the subjective and the objective probability of the high outcome.

#### 4. Economic outcomes with log utility

In this section we look in more detail at the outcomes for income, consumption and international asset allocation in the event that, ex post nature chooses the low outcome. Leaving aside the Autarky case, where allocations simply match endowments, we consider three scenarios, the baseline and the two cases of moral hazard discussed above. Finally, we capitalise the flows in these scenarios to assess what these might imply in terms of losses as percentage of US GDP.

## 4.1 State contingent plans and their financing.

	$P^H$	$P^L$	R	Shares issued	Debt issued	Home deficit	$C_2^H$	$C_2^L$
Baseline $\pi=0.5$								
Global	0.465	0.474	6.5%	4.7	0		211.8	207.8
Home				2.4	1.1	+1.2	107.2	105.1
Foreign				<b>2.3</b>	<b>-1.1</b>	<b>-1.2</b>	104.7	102.7
CMH $\pi=0.75$								
Global	0.698	0.237	7.0%	5.9	0		211.8	207.8
Home				3.0	1.5	+1.4	107.4	105.4
Foreign				<b>2.9</b>	<b>-1.5</b>	<b>-1.4</b>	104.4	102.4
FMH $\pi=0.8125$								
Global	0.756	0.178	7.1%	6.1	0	200	211.8	207.8
Home				3.1	1.5	+1.5	107.4	105.4
Foreign				<b>3.0</b>	<b>-1.5</b>	<b>-1.5</b>	104.4	102.4

Notes.

CMH denotes Corporate Moral Hazard

FMH denotes Full Moral Hazard, i.e. CMH plus Meta-Moral-Hazard.

The Arrow-Debreu prices are discounted back to first period, so  $P^H + P^L = 1/(1 + R)$

Deficit denotes home current account deficit in period 1, as % of GDP.

Figures in bold show how the Foreign acquisition of shares is financed (approx. half by issuing debt).

### Baseline case

With a real interest rate of 7% and a US current account of 1.2%, these outcomes closely match the results in BMW. What these simulations also provide are state-contingent consumption plans, and the asset positions taken to implement them. Instead of the US absorbing all the risk of the New Economy while the foreign economy enjoys consumption stability, both countries share the aggregate consumption risk. Details of the asset positions in the middle of the table reveal that, in addition to investing the current account surplus of 1.2% of GDP in risky US assets, the foreign

country levers this position so as to acquire almost half of the value of shares in the US “New Economy” by borrowing 1.1% of the GDP.

What happens if high payoff the “New Economy” fails to materialise and the low payoff is observed is shown in the last two columns: US consumption is slightly less than its endowment, while the foreign consumption is slightly higher than its own endowment.

### **Corporate Moral Hazard**

Encouraged by high subjective probabilities they attach to high payoffs, foreign investors provide additional funds for increased US consumption in period one, in exchange of shares in the “New Economy” whose present discounted value rises to almost 6% of GDP (in this two period analysis) and continue to leverage their holdings with borrowing that doubles their holdings. Interest rates rise to seven percent.

When leveraged bets go bad, foreign residents suffer strikingly from their exposure to US markets. As the results for the low payoff in the last two columns show, foreigners consume only their own endowment in period two: they get nothing on their savings in period one!

### **Corporate moral hazard plus “meta moral hazard”**

The first period US current account deficit now rises slightly to 1.5% of the GDP. Compared with the corporate moral hazard scenario, there is no increase in foreign leverage; so each country consumes its endowment in period two.

## **4.2 Losses in the US stock markets and their international transmission**

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.<sup>17</sup> 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), corporate moral hazard, 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*

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<sup>17</sup> See Greenspan (2002).

as they take account of both the distribution of possible out-turns and of the delay before they occur; 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.

Table 8: 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 \$trillion
A	<b>BASELINE</b>						
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	<b>Actual Payoff</b>	<b>3.0</b>	<b>52</b>	<b>0.948**</b>	<b>49</b>	<b>\$4.9</b>	
5 = 3-4	Losses				32	\$3.2	\$1.6
B	<b>CORPORATE MORAL HAZARD</b>						
1B	High payoff	7.0	121	0.698	84		
2B	Low payoff	3.0	52	0.237	12		
3B	Expected payoff	6.0			96	\$9.6	
5B = 3B-4	Losses				47	\$4.7	\$2.3
C	<b>FULL MORAL HAZARD</b>						
1C	High payoff	7.0	121	0.756	92		
2C	Low payoff	3.0	52	0.178	9		
3C	Expected payoff	6.25			101	\$10.1	
5C=3C-4	Losses				52	\$5.2.	\$2.5

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.

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 corporate moral hazard. For if conflicts of interest succeed in raising the perceived probability of the high payoff of the “New Economy” from 0.5 to 0.75, the *ex ante* stock valuation approaches the value of annual US GDP; and the corresponding fall becomes \$ 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 perceived policy ‘guarantees’ further reduce downside risk. With a subjective downside probability of only 0.1875, for example, market values rise to \$10.1 trillion, *i.e.* marginally higher than the value of one year’s US national output. If the low outcome transpires and misperceptions are corrected the market will fall by \$ 5.2 trillion. This loss is less than the figure given by Greenspan for the whole market, but it matches the fall in the market capitalisation of the Nasdaq, *i.e.* the losses after the “New Economy” boom.

To distinguish between ‘misfortune’ and moral hazard in these results, note that about 60% of the market fall the 5 trillion dollar fall is due to bad luck and would have occurred with correct expectations, the rest is due to mispricing -- about 30% due to corporate moral hazard (defined as the high payoff for the “New Economy” being assigned a “perceived” probability of more than 0.75) and 10% due to meta moral hazard. Naturally, these fractions reflect the subjective probabilities chosen to characterise the various scenarios, and can be changed accordingly.

The figure of \$2.5 trillion appearing at the foot of the last column indicates that in a one-good model of two symmetric blocs and no home bias, almost half of the total loss would be absorbed by shareholders outside the US. The results of an exercise to estimate losses on EU investments in the US were reported in Castren et al( 2003) to amount to only about \$0.5trillion. This is much less than the symmetric model suggests, but it serves to illustrate the potential for international business cycle transmissions via the wealth channel. Perhaps, to take account of home bias and allow for

non-EU foreign holders, one should take only a quarter of the transfer effects of stock market losses occurring in the model as realistic.

## 5. Conclusions

In intertemporal optimising models of the open economy, current account developments typically reflect consumption-smoothing of idiosyncratic shocks, with an expected supply-side shock of 5% leading to a deficit of over 1% of GDP for example, BMW (2001). When stochastic elements are added -- as in our 2 by 2 by 2 approach -- the capital account reflects global risk-spreading, as well as the financing of inter-temporal trades. In our theoretical model, for example, it is optimal for foreigners to leverage their share-holdings to buy twice as much as needed to finance the US deficit -- and to absorb half the market losses<sup>18</sup>. The welfare gains of such enormous position-taking are, however, distinctly modest: a flow gain of only one hundredth of one percent of consumption to each country, much the same as Lucas's well-known estimate of the benefits of consumption stabilisation. (An important caveat is that, as the payoffs and probabilities are exogenous, these calculations do not try to measure the benefits of stock markets for *creating* high-tech miracles.)

It has to be acknowledged that capital markets are subject to asset-mispricing due to distorted incentives and false accounting in the corporate sector. Even in the US this has proved a serious issue, hopefully much diminished with the passage of the Oxley-Sarbane act that requires corporate officers to certify the validity of financial statements upon pain of imprisonment. By allowing for temporary asset mispricing, our calibrations indicate that moral hazard will have international implications, as foreign shareholders share in the costs of asset price corrections. It is not difficult for the transfers involved to swamp the small welfare gains created by the markets. Even if foreign losses from Corporate Moral Hazard were only a quarter of the values computed in Section 3, for example, they would still be many times larger than the welfare gains derived from these markets.

Artis et al (2003) find that financial factors play a role in their econometric account of why “despite some anticipations to the contrary ... the European economy was strongly affected by the downturn in the US” -- a synchronisation which they note “may be temporary and a result of common shocks



affecting these economies”. Though highly stylised, our model offers a theoretical account for these econometric results.

If, indeed, substantial ‘transfers’ to the US arose from moral hazard, it implies that global financial integration needs to be matched by appropriate financial regulation. The case of emerging markets throws up an interesting contrast, however. When rapid integration of key emerging markets into the world economy took place in the 1990s, it was also in the context of deregulation - that was then the fashion: but in that case it was essentially the borrowers who suffered (very substantial) welfare losses, unlike the host country in our simulations. Why should the fate of those who seek external finance for their economic development differ so greatly? Technically the reason is that emerging markets generally used bond finance and short term bank borrowing, unlike the longer-term, state-contingent claims in the Arrow-Debreu solutions used here to describe investment in the New Economy. Such portfolio choices seem to reveal an instinctive mistrust in the promises of progress in emerging markets, allied with too- touching faith in the New Economy claims that circulated in developed markets. As the temptation to mislead investors is surely ubiquitous - though subject to regulatory and reputational checks - an encompassing approach showing this would be an attractive next step.

The real exchange rate implications of idiosyncratic shocks ideally require the inclusion of differentiated traded goods. Such an extension could show why the strength of the dollar in anticipation of the “New Economy” need not be followed by symmetric dollar weakness (because losses on leveraged investment in the US can wipe out the real transfer that foreign lenders would expect to receive for financing the US deficit): and it could lead to an endogenous rationale for ‘home bias’ in investor portfolios.

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<sup>18</sup> Had the US financed its widening current account deficit with fixed coupon debt US consumers would have had to absorb the full impact of the market fall when the bubble burst in 2000: with equity financing, the losses involved were globally distributed.

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## Appendix 1

### 1. Proof of Proposition 1

To obtain the Arrow-Debreu prices, first combine (2.9) -- (2.12) to yield

$$C_2(s) = [\pi(s) / p(s)]^{1/\rho} P^{1/\rho} \left[ \frac{\beta(1+r)}{P} \right]^\sigma C_1 \quad (\text{A.1})$$

Substitution of (A.1) into (2.16) and solving for  $p(s)$  yields

$$p(s) = [\beta(1+r)]^{\sigma\rho} P^{1-\sigma\rho} \pi(s) [Y_2^W(s) / Y_1^W]^{-\rho} \quad (\text{A.2})$$

Summing both side over  $s$  and rearranging gives

$$P^{1-\sigma\rho} = \frac{[\beta(1+r)]^{-\sigma\rho}}{\sum_s \pi(s) [Y_2^W(s) / Y_1^W]^{-\rho}} \quad (\text{A.3})$$

Substitution of (A.3) into (A.4) gives (2.18).

To obtain the equilibrium real interest rate, combine (2.11) and (2.12) and substitute into (2.15) to give

$$\sum_s p(s) Y_2^W(s) = [\beta(1+r)]^\sigma P^{1-\sigma} Y_1^W \quad (\text{A.4})$$

Substituting (2.18) and  $P$  from (A.3) into (A.4) and simplifying, one can show

$$\begin{aligned} \beta(1+r) &= \frac{(Y_1^W)^{-1/\sigma}}{\sum_s \pi(s) [Y_2^W(s)]^{-\rho}} \left\{ \sum_s \pi(s) [Y_2^W(s)]^{1-\rho} \right\}^{(1-\sigma\rho)/[\sigma(1-\rho)]} \\ &= \frac{(Y_1^W / \Omega^W)^{-1/\sigma}}{\sum_s \pi(s) [Y_2^W(s) / \Omega^W]^{-\rho}} \end{aligned} \quad (\text{A.5})$$

Substitution of (2.18) into (2.10), and incorporating (2.17) yields (2.20).

### 2. Proof of Proposition 2

The proof that consumption in any state and time is of equal proportion to its corresponding world endowment is given in Obstfeld and Rogoff (1996, chapter 4). Here we represent this fraction as exogenous variables when  $\rho\sigma \neq 1$ .

Note we can rewrite (2.11) as

$$C_1 = \frac{W_1}{\{1 + \beta[\beta(1+r)/P]^{\sigma-1}\}Y_1^W} Y_1^W$$

so

$$\mu = \frac{W_1}{\{1 + \beta[\beta(1+r)/P]^{\sigma-1}\}Y_1^W} \quad (\text{A.6})$$

Substitution of equilibrium prices (2.18) – (2.20) to (A.6) and simplifying gives (2.21).

### 3. Proof of Proposition 3

Since equilibrium consumption at any state and time is of the same proportional to its corresponding world endowment, then we must have

$$\Omega = \mu \left\{ \sum_s \pi(s) [Y_2^W(s)]^{1-\rho} \right\}^{1/(1-\rho)} = \mu \Omega^W. \quad (\text{A7})$$

Together with the fact that  $C_1 = \mu Y_1^W$ , one can obtain (2.22).