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ABSTRACT

Fear and Market Failure: Global Imbalances and 'Self-insurance'*

Two key issues are examined in an integrated framework: the emergence of global imbalances and the precautionary motive for accumulating reserves. Standard models of general equilibrium would predict modest current account surpluses in the emerging markets if they face higher risk than the US itself. But, with pronounced Loss Aversion in Emerging Markets, their precautionary savings can generate substantial 'global imbalances', especially if there is an inefficient supply of global 'insurance'. A combination of fear and market failure generates imbalances as a general equilibrium outcome. In principle, lower real interest rates will ensure aggregate demand equals supply at a global level: but disequilibrium may result if the required real interest rate is negative.

A precautionary savings glut appears to us to be a temporary phenomenon, however, destined for correction as and when adequate reserve levels are achieved. If the process of correction is triggered by 'Sudden Stop' on capital flows to the US, might this not lead to 'hard landing' that is forecast by several leading macroeconomists? When precautionary saving is combined with financial panic, history offers no guarantee of full employment.

JEL Classification: D51, D52, E12, E13, E21, E44 and F32
Keywords: liquidity trap, loss aversion and stochastic dynamic general equilibrium

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Non Technical Summary

Are the present current account imbalances – including notably a US external deficit now running at 7% of its national output – part of the normal ebb and flow of trade and finance; or are there special factors at work? Is laissez faire the appropriate policy or is there a case for policy coordination? It depends who you ask.

According to Nouriel Roubini, looking for factors to account for current global imbalances is rather like solving a 'whodunnit': and the two most plausible culprits turn out to be the US and Asia. He notes, for example, that from 2000 to 2004 US fiscal policy showed a large swing into deficit of almost 6% of GDP. But matters have, he argues, changed since 2005: the US fiscal deficit has shrunk somewhat but the external deficit continues to widen. The 'global savings glut' identified by Mr Bernanke, allied with weak investment in East Asia following the crisis experience of 1997/8 are named as key factors.

A very different perspective is offered by David Backus and co-authors, however. They bridle at the use of the term global imbalances; and by the same token they reject the idea of looking for special factors or 'culprits' associated with them. What we observe, they suggest, is business-as-usual: for this no special explanation (nor any policy initiatives) are required.

To investigate how plausible it is that standard optimising behaviour explains what we observe – and, if not, what special factors need to be introduced - we employ a simple global model of trade and finance which incorporates elements of higher risk faced in emerging markets.

What we find is that an orthodox general equilibrium approach fails to produce significant imbalances, in part because of assuming that efficient competitive asset markets spread risk globally. To this extent, we must part company from Backus and co-authors. But things change when we go further to introduce unorthodox features into the model: then, the general equilibrium approach does produce imbalances.

What are these factors? We refer to them in summary fashion as fear and market failure. The former refers to the scarring effects that the East Asia crisis has had on countries in the region; for which the concept of Loss Aversion is introduced in modelling aggregate demand by emerging markets. The latter refers to the absence of efficient means to spread the risk.

Even when countries are profoundly loss averse - determined to avoid the downside consumption shocks of the recent past – we find that efficient asset markets can, in principle, provide the necessary assurance without a savings glut. It is when appropriate insurance is not available that fearful consumers self-insure through saving, and global imbalances begin to emerge. Our approach is one in which we integrate the precautionary motive for accumulating reserves into a model of global imbalances.

Joseph Stiglitz remarks that "The East Asian countries that constitute the class of '97 – the countries that learned the lessons of instability the hard way in the crises that began in that year – have boosted their reserves in part because they wanted to make sure that they won't need to borrow from the IMF again. Others, who saw their neighbours suffer, came to the same conclusion – it is imperative to have enough reserves to withstand the worst of the world's economic vicissitudes." A combination of fear and market failure generates this scenario as a general equilibrium outcome.

The effect of precautionary behaviour in depressing real interest rates (and possibly employment) is, however, checked by the US acting as 'consumer-of-last-resort'. But there are risks for the global economy. In the immediate short run, interest rates might hit a floor – the so-called Liquidity Trap – where the consumer of last resort fails to match precautionary savings, and global demand falls below supply. This is especially true if those outside the US are no longer willing to accumulate US debt and the US is faced with a 'Sudden Stop' in its deficit financing

Over the longer run, we have effectively assumed that demand in Emerging Markets will rise strongly when adequate reserve levels have been achieved. But this may well be excessively optimistic – posing similar issues of adjusting demand in the longer term. The simplifying assumption of only one good conceals the need for exchange rate changes to accompany this adjustment – as described by Obstfeld and Rogoff – and the need to avoid exchange rate "overshooting" along the way.

Roubini sees an important role for the IMF in this process of adjustment. This may well prove to be true. But it will surely involve a substantial change from the current situation, where the behaviour of emerging markets reflects considerable fear and mistrust of global financial markets – and a loss of confidence in the IMF. As Martin Wolf has observed: "the failure to create stable net flows of capital from the rich world to the poor one is arguably the greatest failure of the second age of globalisation".

Introduction

Current forecasts of global growth may be benign, but they pose interesting puzzles. If growth is expected to proceed at a healthy rate, why are real interest rates so low (Greenspan's conundrum)? If the current account US deficit proves unsustainable, how is it to adjust? Will this be assisted by policy coordination[4], as for the dollar in the 1980s: or can it be left to market forces? Before developing a simple global model to show how low real interest rates around the world and high savings outside the USA may be explained by attitudes towards risk, we briefly outline some influential but contrasting views currently in circulation[5].

Bretton Woods 2; 'Charles River' reactions; and 'Dark Matter'

To understand current events some argue that one needs to look back fifty years to the creation of the Bretton Woods system of fixed-but-adjustable exchange rates. Then, after WW II was over, the major economies of Europe pegged against the US dollar at exchange rates low enough to permit export-led recovery and a reconstitution of reserves. Now, in the 21st century, it is not recovery from war but emergence from relative poverty that dictates the choice of regime; and the currency that is effectively pegged against the dollar is the Chinese remnimbi in what Dooley et al. (2004) call a *revived Bretton Woods* (hereafter BW2).

In their eyes, a policy of export-led growth, giving jobs to the millions who are leaving the land to seek jobs in manufacturing, makes good sense for China, now and for some time to come. And China is willing to hold the US securities that are financing the counterpart US deficits, a ready store of liquidity available to head off virulent financial panic of the type that swept East Asia in 1997/8. (If that was like a bank run, as Jeffrey Sachs suggested at the time, China is now enabled to act as a regional lender-of-last-resort, and it is in fact party to regional swap arrangements to boost confidence, Kohlscheen and Taylor, 2006).

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[4] As argued recently by the Governor of the Bank of England (King, 2006).
[5] A more comprehensive list is to be found in Roubini (2006).

Support for the viability of BW2 has been provided by Richard Cooper of Harvard University, a close observer of the Chinese scene, who argues that investing domestic savings in dollars makes good sense for a country plagued with *insecurity of property rights*. This view effectively attributes to the US an 'exorbitant privilege' akin to monopoly in the issue of money as a liquid store of value: so the US is exporting security of ownership in exchange for cheap manufactures of goods.

Cooper's view has been provided with intriguing theoretical underpinning in a recent paper whose first author is at nearby MIT. Caballero et al. (2006) specify an infinite horizon OLG model of global demand and supply, where one group of countries is *restricted in its ability to capitalise on future earnings*. They show how this reduces the group's effective wealth in global capital markets, lowering world interest rates and redistributing consumption towards countries that are not so restricted. Conditional on the existence of such capital market constraints, the constellation of low real rates and 'global imbalances' is an equilibrium phenomenon. The idea that agents whose budget constraints reflect current income rather than expected future flows will restrict their consumption accordingly may sound rather Keynesian; but, on their analysis, the restriction leads to lower interest rates not unemployment.

Rather than shackles that may hobble Asian economies, Hausmann and Sturzenegger (2005) appeal to the quasi-monopoly power of the US to explain the viability of the current regime[6]. The country may be running deficits as conventionally measured, but this is offset, they argue, by the acquisition of assets that are improperly accounted for. The missing elements, so-called *dark matter*, reflect quasi–rents in three areas: in the issuance of money in the form of dollar bills (seigniorage); in the provision of secure assets for a risky world; and in the supply of entrepreneurial know-how (adding 'goodwill' to US FDI).

[6] An analysis that may find support in Meissner and Taylor (2006).

The Transfer Problem; the Peso Problem; and the Risk of Recession

The sanguine view of a revived and relatively durable BW2 has been subjected to persistent and detailed criticism from academics, market watchers and think tanks, many located in the US itself. What then of those who see cracks in the edifice, signs of the demise of a regime created by peradventure and sustained by US deficits which would merit severe downgrades for any other sovereign borrower?

Obstfeld and Rogoff (2005), for example, judge the pattern of global imbalances to be unsustainable. To calibrate the adjustments needed to correct for this they appeal to an earlier historical episode – the transfer of resources from Germany to the Allies after WWI. Since the US is absorbing more than it produces (*pace* Hausmann and Sturzenegger), this will have shifted the real exchange rate, with the terms of trade moving in favour of US exports and the price of non-traded goods in the US rising relative to foreign counterparts. As and when the US curbs its absorption, the real exchange rate must adjust to reflect the shift of global demand. This may require a 30% devaluation of the dollar (a weighted average of a 10% shift in the terms of trade and 40% shift in the relative price of non-traded goods, very approximately).

Their timely treatment is, however, subject to two criticisms. First, the model is static so it has little to say about the global interest rates. It is an account of general equilibrium in a global endowment economy, with inter-temporal issues left to one side: the US deficit continues until, at some unspecified date, capital markets cry halt and the dollar falls to secure the appropriate reallocation of consumption. Second, in the process of adjustment it is assumed that national income constraints mimic those of a "transfer" problem; but it is far from clear why unilateral action by the US to reduce absorption will lead to expanded absorption elsewhere, especially if the trigger for the US adjustment is a 'Sudden Stop' in capital flows to the world's largest economy.

Assuming that the end of BW2 will involve a significant dollar devaluation, this should surely have implications for the global pattern of interest rates. Indeed, as Jim

Hanson has pointed out[7], it implies existence of a 'peso problem'. If people expect a 30% dollar devaluation at some random time, then US assets should offer a devaluation premium. A peso problem in emerging market economies pushes their interest rates above the US rate: in this case, however, it is the rest of the world that adjusts. Given that the US sets rates, other countries have to pump in liquidity to lower theirs. This offers an alternative explanation for low rates to the capital constrained view of Caballero et al. (2006); and a prediction for US/ non-US differentials that does not exist in their model.

Nouriel Roubini and Brad Setser have expressed persistent doubts as to how long current imbalances can be sustained, Roubini(2006), Setser (2006). Their scepticism is shared by Fred Bergsten and his colleagues at the IIE who have been calling for a dollar devaluation for some time, Bergsten and Williamson (2004). Their calculation of a multilateral adjustment of exchange rates implicitly rejects the view taken in some quarters that 'the Euro is no part of the problem, so it is no part of the solution'. Insofar as these calculations assume no collapse of global demand they may, like Obstfeld and Rogoff, be assuming effective 'transfers' (or they may be assuming successful monetary stabilisation of world demand). Martin Wolf is perhaps the most widely-read proponent of the view that substantial rebalancing of global demand and adjustment of exchange rates is necessary for sustainability.

It is a matter of history that the transfers mandated by the victorious allies after WWI were followed not by smooth economic adjustment but by falling demand and, ultimately, by the Great Depression. This may well be the historical precedent that prompts the warnings of possible disaster made by Barry Eichengreen, an expert on the Gold Standard and its collapse. He and Yung Park of Seoul University outline a scenario where a 'Sudden Stop' in the lending to the US leads to a collapse in the dollar with rising interest rates to prevent overshooting (and an accompanying collapse of asset prices, especially housing): and the combination of rising rates and falling demand in the US leads to deficient demand at a global level (Eichengreen and Park, 2006).

[7] In his contribution to the conference on "Global Imbalances and Risk Management Has the center become the periphery?", Madrid May 2006.

Table 1 provides a brief summary of these views, classified by whether the need to adjust the pattern of global demand and/ or the need to adjust the dollar exchange rate is seen as a major problem.[8] Outright optimism, which sees neither as a problem, appears in the upper left right corner, represented by Hausmann and Sturzenegger - for whom Dark Matter dispels all doubts – and by Backus et al. (2006). Pessimists, who see both issues as needing adjustment appear in the bottom right, including Setser (2006), Eichengreen and Park and Martin Wolf.

	No exchange rate problem	Some dollar overvaluation	Unsustainable overvaluation
No imbalance of demand	H and S: "Dark Matter" Backus et al.		
Some demand imbalance	Cooper Caballero et al: "Constrained Equilibrium"		Dooley and Garber: "BW2" Obstfeld and Rogoff: "The Transfer Problem"
Unsustainable demand imbalance	Our view		Roubini and Setser Bergsten and Williamson Eichengreen and Par Martin Wolf

Table 1. Global imbalances and the dollar: differing assessments

Between these poles are two other groups. First, Dooley and Garber with their BW2 perspective, where benign US deficits are sustainable for some time to come.[9] Second, those who see the savings glut as sustainable long-term for institutional reasons: this 'Charles River School' includes both Cooper and Caballero *et al*.

The integrated approach proposed in this paper differs from all the above[10]: it explains the emergence of the global imbalances as a result of precautionary behaviour by emerging markets exacerbated by incomplete markets for insurance. Empirical evidence of precautionary behaviour on the part of emerging markets is documented

[8] For an alternative summary, listing ten causes of current imbalances, see Roubini (2006).
[9] This perspective, where international reserve accumulation is triggered by concern about export competitiveness, is referred to as Mercantilist view in Aizenman and Lee (2005).
[10] Because we use a one-good model it belongs at the foot of the first column of the Table: but an extension with more goods would appear in bottom right.

in Aizenman and Lee (2005, p8) who find that "In terms of horse race between the mercantilist and precautionary views of international reserves, our results suggest that the precautionary motive played a more visible role … than the mercantilist motive."

The paper is structured as follows. Using the Fisherian inter-temporal approach, Section 2 briefly looks at the savings when there is no uncertainty. Section 3 develops the benchmark model of general equilibrium with uncertainty where risk in the Emerging Markets (henceforth referred to as 'EM') is shared with the US without substantial surpluses or deficits. Section 4 introduces loss aversion and precautionary saving. In the absence of complete markets, substantial risk can lead to substantial imbalances and negative real interest rates. Interestingly, the absence of insurance allows us to use Fisher's approach to characterise a global equilibrium of fear and market failure. Section 5 discusses whether strategic factors may account for the limitation of insurance markets. Section 6 discusses sustainability and the temporary nature of the precautionary savings. Section 7 considers the possible emergence of Keynesian equilibrium due to a Liquidity Trap and/ or a 'Sudden Stop' in capital flows. Section 8 concludes that a savings glut could lead to deficient world demand if it is combined with financial panic that prevents the US from acting as "consumer of last resort".

2. External Imbalances and Irving Fisher

Irving Fisher viewed savings and investment decisions from the perspective of optimising consumption over time[11]: and applying this perspective to countries involved in international trade has led to the now-popular inter-temporal approach to the balance of payments. As Obstfeld and Rogoff (1996, Chapter 1) express it, "Much of the macroeconomic action in an open economy is connected with its inter-temporal trade, which is measured by the current account of the balance of payments".

Before introducing our general equilibrium approach, which includes risk as well, we sketch three variants of the neo-Fisherian perspective that bear on the current debate. First that current account imbalances may reflect international differences in growth

[11] As, in a full employment context, did Keynes and Ramsey (1928).

rates, as suggested by Backus et al. (2006); second that, with no growth differentials, imbalances may reflect capital market constraints, as in Caballero et al. (2005); a third, closely-related possibility is that behaviour may be reflecting insecure property rights in the EM, the Cooper hypothesis. These can be illustrated simply as in Figure 1.

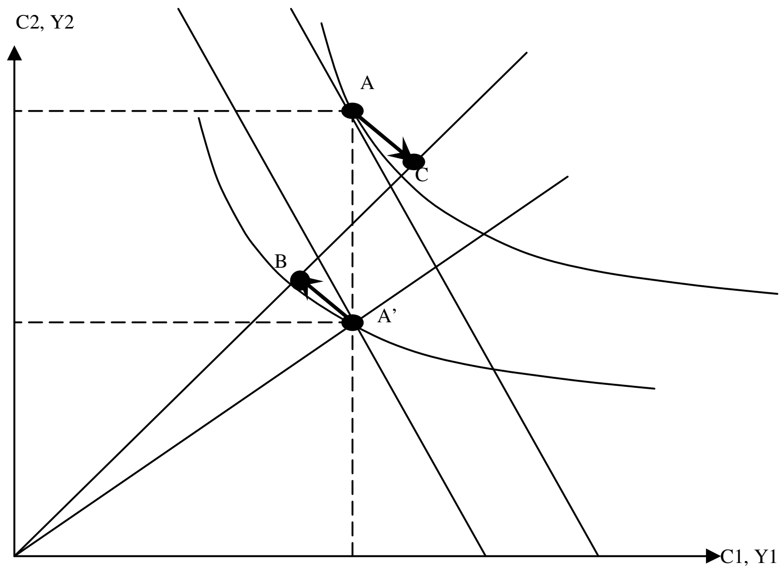

Figure 1. Fisher diagram: differentials in growth, wealth constraint and pessimism

First let the endowment of the US be at point A and that of EM at A', the former exhibiting high growth and the latter no growth. Given identical tastes, these *growth differentials* provide incentives for inter-temporal trade. The US can smooth consumption by consuming EM saving at interest rates lying between the pure rate of time-preference shown at A' and the much high rate of inter-temporal substitution at point A (where the slope of the indifference curve also reflects the high growth rate). The equilibrium trade vectors are shown by A'B and AC and both countries end up consuming on the same ray from the origin. We believe this captures the spirit of the "business-as-usual" global equilibrium perspective of Backus et al. (though it is admittedly something of a caricature as growth differentials are taken as exogenous).

Next assume by contrast that *both* countries have identical endowments at point A. While the US consumes with the appropriate inter-temporal budget constraint, let the EM be constrained to lower budget line passing through A' as might be the case if *capital markets fail* to take due account of future endowments. The consumption and savings in period 1 will be precisely the same as for the case of growth differentials. Could this represent the capital-constrained perspective of Caballero et al? (Probably not, because it would not be sensible for EM to save knowing that it is about to receive the same endowment as the US!)

But what if consumers in EM are not sure that they will secure the extra output- because of ill-defined property rights, as Cooper says is true in China? Then they might act 'as if' their expectations of the growth in EM were unduly pessimistic – as if they expected output in EM to be stationary, for example. In which case, despite the fact that both countries have identical endowments at point A, insecure ownership might lead to the same high savings in EM and low global interest rates as predicted Backus et al.

These inter-temporal accounts are essentially deterministic: would a stochastic specification have something more to offer? This is what we explore next, first with standard (logarithmic) preferences and then with the introduction of loss aversion. With the addition of market failure, we find that loss aversion generates a constrained equilibrium rather similar to that of Cabbellero et al. and Cooper.

3. General Equilibrium with Complete Markets

To incorporate risk, we use a simplified dynamic stochastic general equilibrium (DSGE) model in the tradition of Mas-Colell *et al* (1995) and Obstfeld and Rogoff (1996). This stylised one good model has two time periods, two states of nature and two countries – the US and EM; and we use the asterisk suffix '*' to denote EM. The framework is similar to that used earlier to study global finance and the US New Economy in Miller *et al* (2005, 2006), though the endowment pattern reflects the traditional situation where the US invests in risky assets and supplies safety and security in exchange (Hausmann and Sturzenegger, 2005).

Rather than postulating growth differentials, with low growth for EM accounting for low world real interest rates and large US deficits, we assume identical expected growth but differential risk. Specifically growth prospects in EM have greater volatility than for the US, modelled by adding a mean-preserving spread. Though this does not have a great impact in a standard general equilibrium framework, results change when downside risk is aggravated by a form of Loss Aversion. (The utility of consumption in period 2 which lies below that reached in the previous period is sharply discounted.) In a stochastic environment, the resulting risk sensitivity can lead the EM to acquire substantial insurance; and to act 'as if' it underestimates the mathematical expectation of growth.

When the relevant insurance is not available (or the provision is not credible), EM can always 'self-insure' – saving instead of swapping financial promises. So the desire to limit downside risk can make EM act 'as if' it has very low time preference as we show in numerical outcomes below. Combining inadequate insurance with Loss Aversion provides a ready explanation for low interest rates, the US deficit and high EM savings.

To put this in context, consider the case of China. After what happened to many East Asian countries in 1997/8[12], it is clear that interruptions to trend growth are perfectly possible: and the rampant Chinese Dragon may be no more immune to shocks than were the Asian Tigers. In the words of Peter Nolan (2004, pp48-49):

> Today, the Chinese economy is growing fast, but the lesson from the past, especially the Asian Financial Crisis, is that perceptions can change overnight. China is today the last remaining large 'Growth story' in the world; it already has a huge 'bubble' of FDI, with the largest FDI inflows of any economy in the world… It is easy to imagine how the bubble might burst, and the flow of capital be reversed, with huge potential de-stabilizing consequences for the economy and society. There would then be a full-blown 'Chinese Financial Crisis'. *A central goal of policy must be to avoid such an outcome*. [Italics added]

If there is concern that consumption on the downside should not fall relative to past levels, China can of course seek insurance by selling FDI and buying US government bonds: and it can also seek to self-insure by acquiring US bonds via the current account. If, for any reason, the first option is limited, then self-insurance will be seen

[12] When, in the crisis, trend growth rates effectively changed sign.

as the only way to avoid an unappealing prospect – the prospect, perhaps, of humiliation like that suffered by its near neighbour South Korea in 1997/1998 when it had to go cap in hand to the IMF and G7 and sacrifice sovereignty to get the financial support it needed in the crisis.[13]

These considerations may suggest that strategic factors play a role that is not captured in the competitive framework we use here[14]– that some sort of insurance market game may be in process. This is discussed briefly in section 4 below.

3.1 The Benchmark Case

The pattern of endowments assumed is indicated in Table 2. Both blocs are endowed with one unit at time one. In expected terms each bloc grows at the rate g, say 3%. In the absence of uncertainty each bloc would consume its endowment and, with log utility, real interest rates would equal growth rate plus the pure rate of time preference. If the latter were, say, 1.5%, this would imply the global real interest rates of 4.5%.

With uncertainty, consider the case where future endowments for EM can take one of two values: high and low, with a standard deviation of σ around the mean rate of growth. (For convenience, each of the two outcomes is treated equi-probable; and in simulations σ varies from 3 to 12 %. But the assumption of symmetry for the shocks to EM growth is made for expositional convenience. The main results are independent of the shape of the probability distribution, as is noted below.)

	USA	**EM**	
		High (with probability π)	Low (with probability $1-\pi$)
Period 1	$Y_1 = 1$	$Y_1^* = 1$	$Y_1^* = 1$
Period 2	$Y_2(1) = Y_2(2) = 1 + g$	$Y_2^*(1) = 1 + g + \sigma$	$Y_2^*(2) = 1 + g - \sigma$

Table 2. The pattern of endowments

[13] Stiglitz (2006, p248) comments "The East Asian countries that constitute the class of '97 – the countries that learned the lessons of instability the hard way in the crises that began in that year – have boosted their reserves in part because they wanted to make sure that they won't need to borrow from the IMF again. Others, who saw their neighbours suffer, came to the same conclusion – it is imperative to have enough reserves to withstand the worst of the world's economic vicissitudes."

[14] We are grateful to Sayantan Ghosal for this observation. It carries the implication that the model of 'unrelentingly competitive' Incomplete General Equilibrium with default studied by Dubey et al (2005) is not really appropriate here.

To study the pattern of savings and world real interest rates, we first present benchmark results where the complete set of Arrow-Debreu securities can be traded. Later we look at how these results may change if the set of securities is restricted or preferences modified. To simplify the exposition of the benchmark results, we assume representative consumers in both countries share identical preferences. Home country's lifetime utility is given by

$$U(C_1, C_2(\cdot)) = \ln(C_1) + \beta[\pi \ln(C_2(1)) + (1-\pi)\ln(C_2(2))] \tag{1}$$

where β is time preference, C_1 and $C_2(\cdot)$ are period 1 and period 2 consumption respectively. The budget constraint of US is given by

$$C_1 + q(1)C_2(1) + q(2)C_2(2) = Y_1 + q(1)Y_2(1) + q(2)Y_2(2) \equiv W \tag{2}$$

where $q(s) > 0$ ($s = 1,2$) are Arrow prices measured in period 1 sure consumption, and W is the present value of US's total wealth.

Given Arrow prices, US's optimal consumption implied by its first order conditions are simply

$$C_1 = \frac{W}{1+\beta}. \tag{3}$$

$$C_2(1) = \frac{\beta\pi}{q(1)} C_1 \tag{4}$$

$$C_2(2) = \frac{\beta(1-\pi)}{q(2)} C_1 \tag{5}$$

Those for EM follow the same forms.

Applying equilibrium conditions, that total consumption in each period and state equals the corresponding total endowment, determines the equilibrium Arrow prices and real interest rates as follows:

$$q(1) = \pi\beta Y_1^W / Y_2^W(1) \tag{6}$$

$$q(2) = (1-\pi)\beta Y_1^W / Y_2^W(2) \tag{7}$$

$$\sum_s q(s) = 1/(1+r) \qquad (8)$$

where superscript W indicates world endowment. The pattern of consumption is obtained by substituting (6) and (7) into (3), (4) and (5).

With the endowments specified in Table 2, EM has an incentive to save in period 1. This is evident from a comparison of EM wealth relative to US wealth. Note that

$W^* = (W - (q(2) - q(1))\sigma) < W$

where σ is the standard deviation of the EM endowment and $q(2) > q(1)$.

Because EM wealth is relatively lower, so is consumption, i.e.

$C_1^* = W^*/(1+\beta) < W/(1+\beta) = C_1$. So EM saves, matched by a US current account deficit. Clearly the more volatile is EM's endowment in period 2 (i.e. the greater is σ), the higher will be its period 1 savings. But with log utility and efficient provision of 'insurance', the savings effects are distinctly modest, as will be seen in Table 3.

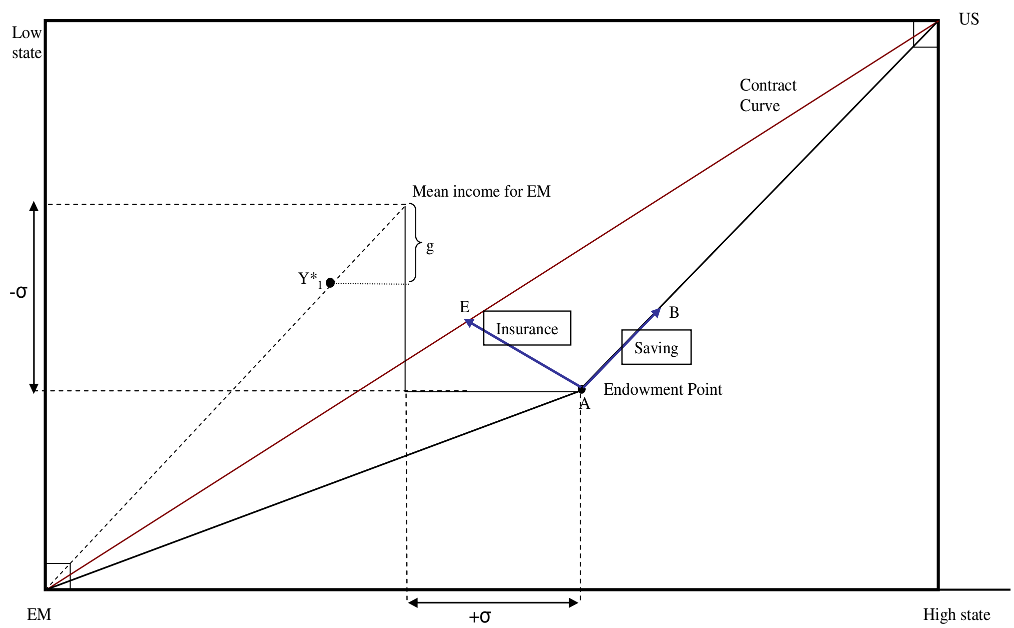

Figure 2. Endowments and trading opportunities in Period 2 – the Edgeworth Box

How securities markets provide this insurance is indicated graphically in Figure 2, an Edgeworth box diagram as in Mas-Colell *et al* (p.593, 1995) describing allocations in period 2. Outcomes for the high payoff state are on the horizontal and for the low payoff state on the vertical, and utility for EM is measured from the lower left corner and that for US from the upper right. Identical probability assessments and utility functions imply that the contract curve is the diagonal in the figure.[15] The autarky endowment point is at *A*, where for the US – identical endowments in both states – this lies on the 45-degree line measured from the upper right corner. For the EM, however, disparity in the endowment between the two states means that it lies to the right of the 45-degree line drawn from the bottom left corner. Ignoring the effect of the first period savings on reallocating entitlements (as they are so small, see Table 3), general equilibrium consumption is shown at point E (on the contract curve).

How much does aggregate risk affect global interest rates and current account imbalances? Not very much, if we use parameter values of $\beta = 0.985$, $\pi = 1/2$, and endowments from Table 2, where average growth is 3% in both blocs.

		$\sigma = 3$		$\sigma = 12$	
Benchmark	US deficit	**0.01**		**0.2**	
	Real interest rate		*4.5%*		*4.2%*
Bonds-only	US deficit	**0.02**		**0.34**	
	Real interest rate		*4.5%*		*3.9%*
LA with complete markets	US deficit	**0.01**		**1.2**	
	Real interest rate		*4.5%*		*3.5%*
LA with bonds-only	US deficit	**0.02**		**4.6**	
	Real interest rate		*4.5%*		*-4.3%*

Table 3. US deficits and the world real interest rates: 4 cases.

Note: LA refers to Loss Aversion. US deficits are measured as percentage of period 1 GDP. All simulations assume equi-probable states; but, for the case of LA and bonds only, the results are in fact independent of state probabilities.

From lines 2 and 3 for the Benchmark case in Table 3, it is evident that stochastic endowments for the EM do lead to some lowering of world interest rates and some increase in the US deficit as the theory predicts: but with log preferences the

[15] The assumption of identical utility is more restrictive than Mas-Colell *et al* (p.693, 1995) where the contract curve is non-linear.

quantitative effects are very small. Increasing the standard deviation from 3% to 12%, for example, only increases the US deficit by one fifth of a percentage point of GDP; and it shaves a mere 30 basis points off the world interest rate.

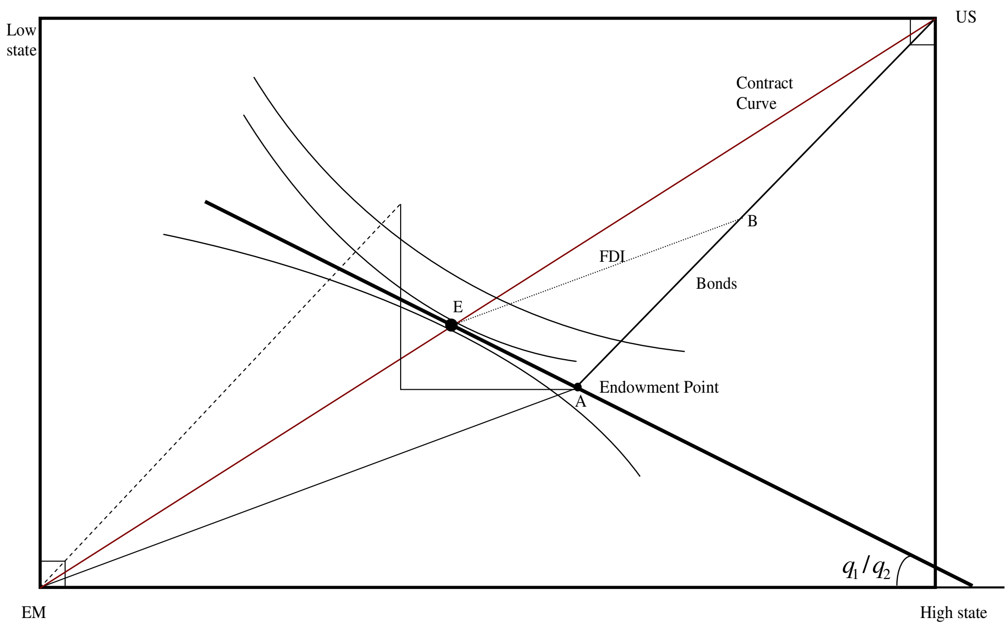

Figure 3: Buying insurance: a swap of GDP-Bonds.

Given the asymmetry of global endowments, consumption risk in the EM is not diversified away: but it is shared as shown in Figure 3. This involves the EM exchanging claims on output in state 1 for claims in state 2 at the relative price indicated by the slope of AE. The slope of this vector in absolute terms is $|q(1)/q(2)| < 1$, reflecting the relative abundance of goods in high state.

In the absence of Arrow securities, what assets might sustain this equilibrium? Consumption at E may be achieved by the sale of GDP-bonds from the US (vector AB) in exchange for GDP-bonds of the EM (labelled FDI in the Figure, see vector BE). Consider sales of US government securities in exchange for FDI in China, for example. For further discussion of GDP bonds, see Griffith-Jones and Sharma (2006), Griffith-Jones and Shiller (2006).

3.2. Equilibrium with no "insurance"

What if the only asset traded between the two countries is a bond which has the same payoff in both states in period 2? In the absence of insurance possibilities, the EM will save more in period 1 to avoid potential utility losses were it to consume its unequal endowments in period 2, and the extra savings will bring down the global rate of interest. This can be shown as follows.

Denote S the first period saving by US (the amount of bonds purchased), its optimal level is determined by the solution to the following problem:

$$Max_S\{\ln(C_1)+\beta[\pi\ln(C_2(1))+(1-\pi)\ln(C_2(2))]\} \quad (8a)$$

subject to

$$C_1 = Y_1 - S \quad (8b)$$

$$C_2(1) = Y_2(1) + (1+r)S \quad (8c)$$

$$C_2(2) = Y_2(2) + (1+r)S \quad (8d)$$

where $(1+r)$ is the gross real interest rates.

As $Y_2(1) = Y_2(2) = Y_2$, the optimal saving implies the period 1 consumption

$$C_1 = \frac{1}{1+\beta}\left(Y_1 + \frac{Y_2}{1+r}\right) \quad (8e)$$

One can solve for a similar problem for EM to yield its period 1 consumption

$$C_1^* = Y_1 - \frac{-\xi+\sqrt{\xi^2-4(1+\beta)\varsigma}}{2(1+\beta)} \quad (9)$$

where

$$\xi = Y_2^*(1) + Y_2^*(2) + \beta[\pi Y_2^*(2) + (1-\pi)Y_2^*(1)] - \beta(1+r)Y_1$$

$$\varsigma = Y_2^*(1)Y_2^*(2) - \beta(1+r)Y_1[\pi Y_2^*(2) + (1-\pi)Y_2^*(1)]$$

Imposing equilibrium condition

$$C_1 + C_1^* = 2Y_1$$

yields the following fixed point condition for real interest rates

$$\left(\frac{Y_2}{1+r} - \beta Y_1\right)^2 + \xi\left(\frac{Y_2}{1+r} - \beta Y_1\right) + (1+\beta)\varsigma = 0 \quad (10)$$

Equations (9) and (10) are used to generate numerical results in lines 4 and 5 for the Bonds-only case in Table 3.

EM saving as percentage of GDP (and the US deficit) is twice as large as in the Benchmark case, but it still remains very small even when standard deviation of the shock to its endowment rises to 12%. With log utility, therefore, eliminating insurance does not predict a savings glut in EM. (The effect of increasing risk on the world interest rate is more pronounced: it falls by 60 basis points, to less than 4%, when the standard deviation increases from 3 to 12%.)

4. Global Equilibrium with Loss Aversion

4.1. Loss aversion with a complete set of Arrow securities

In this section, we modify the preferences of the EM by incorporating two elements from Prospect Theory (Kahneman and Tversky, 1979): namely, *reference dependence* and *loss aversion*. We assume that consumption achieved in the previous period acts as a reference in the current period, so the measurement of utility depends on whether there is a "loss" or a "gain" in current consumption relative to this reference. To capture loss aversion, we assume that, close to the reference point, the increase in utility of a unit "gain" in current consumption (relative to the reference) is much smaller than the decrease in utility of a unit "loss" in current consumption.

Specifically, let the utility of state i consumption be defined as

$$u(C_2^*(i)) = \begin{cases} \ln(C_2^*(i)/C_1^*) & if \quad C_2^*(i) \geq C_1^* \\ \lambda \ln(C_2^*(i)/C_1^*) & if \quad C_2^*(i) < C_1^* \end{cases} \tag{11}$$

where $\lambda > 1$ indicates the degree of loss aversion. (Note that the utility measure becomes negative for consumption below reference level.)

To make the following treatment tractable, we consider a limiting case of loss aversion, namely, $\lambda \to +\infty$. Under this simplification which implies extreme disutility of any contraction of consumption, (11) is equivalent to imposing the constraint that

$$C_2^*(i) \geq C_1^* \qquad (12)$$

The procedure used here, of imposing the constraint that next period's consumption in any state of the world should not fall below consumption in the current period, could also be viewed as an extreme form of *habit formation* as widely used in macroeconomic models. Chari, Kehoe and McGrattan (2002), in their attempts to determine whether sticky prices can lead to volatile and persistent real exchange rate movements, for example, assume in one experiment that the utility from consumption depends not on current consumption but its level relative to a fraction of last period's aggregate consumption. A similar formulation has also been used by Campbell and Cochrane (1999), Carroll, Overland, and Weil (2000), Ravn, Schmitt-Grohe, and Uribe (2004). As Carroll *et al* show, with this form of habit-persistence in consumption, higher growth may lead to higher saving.

In what follows, we show that loss aversion can also increase savings, but only if consumption would otherwise have fallen below the reference trigger. With complete contingent securities, US optimal consumption is derived in the same way as in Section 2.1. But EM's optimal consumptions are solutions to the following problem:

$$Max_{C_1^*, C_2^*(i)} \{\ln(C_1^*) + \beta[\pi \ln(C_2^*(1)) + (1-\pi)\ln(C_2^*(2))]\} \qquad (13)$$

subject to the budget constraint

$$C_1^* + q^{LA}(1)C_2^*(1) + q^{LA}(2)C_2^*(2) = Y_1^* + q^{LA}(1)Y_2^*(1) + q^{LA}(2)Y_2^*(2) \equiv W^* \qquad (14)$$

and (12).

How does loss aversion in EM change the equilibrium prices and allocation? We summarise these results in the following propositions.

Proposition 1. If $\sigma \leq 2g$, equilibrium prices and allocation are the same as those in Section 2.1.

Proof: See Appendix A.

Note that with complete Arrow securities, both countries can share risks. This risk-sharing means that both countries consume more or less equal proportions of the aggregate state endowment. So if the standard deviation of EM endowment in period 2 is small, EM is effectively insured against low consumption in the bad state. Therefore, no additional saving is required.

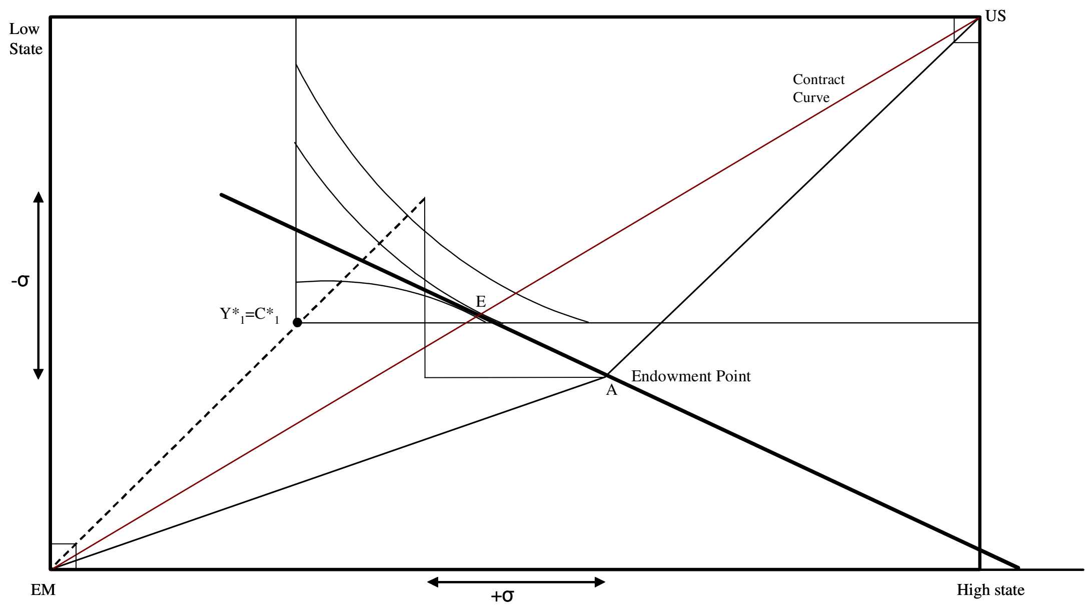

Figure 4a. Unchanged equilibrium when the loss aversion constraint fails to bind

Proposition 1 is illustrated in Figure 4a, where point E represents optimal consumption allocation with loss aversion. The loss aversion constraint is represented the L-shaped lined emanating from the point $Y_1^* = C_1^*$, and all EM consumption allocations to the north-east of this point satisfy the constraint. As point E lies on the contract curve north-east of point $Y_1^* = C_1^*$, the loss aversion constraint is not binding; and equilibrium in Figure 4a is identical to that in Figure 3. When risk increases, however, equilibrium can change as indicated in the following proposition.

Proposition 2. For the endowment structure given in Table 2, if $\sigma > 2g$, then

(1) $q^{LA}(1) > q(1)$ and $q^{LA}(2) > q(2)$;

(2) $q^{LA}(2)/q^{LA}(1) > q(2)/q(1)$;

(3) $r^{LA} < r$;

(4) $C_1^*(LA) \leq C_1^*$.

(5) $C_2^*(2, LA)/C_2^*(1, LA) > C_2^*(2)/C_2^*(1)$

Proof: See Appendix B.

Results in Proposition 2 are quite intuitive. If the standard deviation of period 2 EM endowment is large, simple risk sharing is not sufficient to ensure that the consumption in the bad state remains above the reference level for EM. So loss aversion increases EM's demand for insurance in period 2. As this raises the relative price $q^{LA}(2)/q^{LA}(1)$, EM also increases savings as a substitute for high cost insurance. (Note that period 1 savings for EM not only act as a substitute for insurance but also reduce the reference consumption in period 2, making the constraint less likely to bind.) Proposition 2(5) implies that consumption allocation in period 2 when loss aversion constraint is binding lies above the contract curve associated with no loss aversion.

Suppose we allow EM to have a different parameters for time preference, β', and the subjective probability parameter, π', while keeping those of US as before, can we replicate the outcomes in Proposition 2 without evoking the assumption of loss aversion? The results for this "as if" exercise are given in the following proposition.

Proposition 3. For a set of parameters $\{\beta, \pi; \beta', \pi'\}$ (and given restriction on endowments as in Proposition 2) to replicate the equilibrium results in Proposition 2, it is sufficient that

(1) $\pi' = \dfrac{\beta\pi(1+q^{LA}(2))}{(1+\beta)q^{LA}(2)+\beta\pi} < \pi$

(2) $\beta' = \dfrac{(1+\beta)q^{LA}(2)+\beta\pi}{1+\beta(1-\pi)} > \beta$

Proof: See Appendix C.

Proposition 3 indicates that the effects of introducing loss aversion on the part of the EM will (when the constraint is binding) be to increase its perceived pessimism ($\pi' < \pi$) and to make it more forward-looking ($\beta' > \beta$).

How loss aversion can impact on global equilibrium is illustrated using Figure 4b, the Edgeworth box used earlier. As before, points A and E represent EM's second period endowment and consumption allocation in the absence of loss aversion. With large enough σ, however, the loss aversion constraint becomes binding and EM will increase its first period savings (Proposition 2(4)), moving its second period effective endowment from A (along the 45 degree line) to B. The binding of the loss aversion constraint will also change relative Arrow prices (Proposition 2(2)), making EM's period 2 budget constraint flatter (see line BE'). The intersection of the budget line BE' with the loss aversion constraint $C_2^*(L) = C_1^*$ defines the new equilibrium E' which lies above the contract curve due to Proposition 2(5). From A, a combination of savings and an asset swap of US bonds for FDI allows for consumption at point E' satisfying the loss aversion constraint.

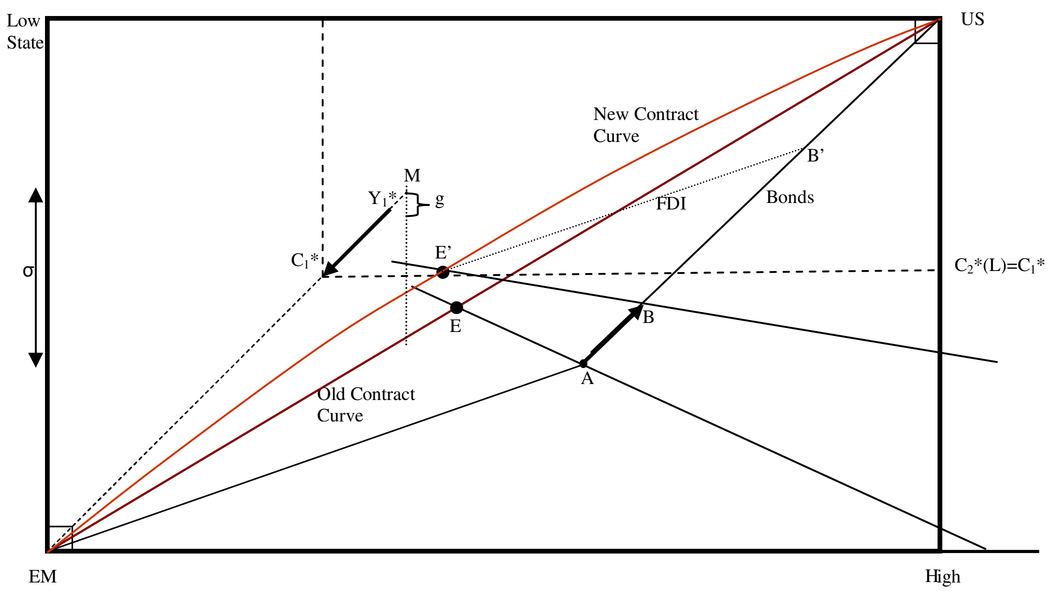

Figure 4b: Savings and insurance with Loss Aversion; it's 'as if' time preference has fallen and pessimism has increased in EM.

As indicated in Proposition 3, this new equilibrium may also be replicated without loss aversion if EM has lower time preference (higher β) and greater pessimism (lower π). As can be seen in Figure 4b, the increase in pessimism in the EM, calibrated by a fall in π'/π, has two effects: first it makes the contract curve concave, and second it changes the relative Arrow prices which makes EM's budget constraint flatter. The decrease in the time preference, calibrated by the increase in

β'/β, has the effect of increasing EM's savings and so shifting its second period effective endowments from A to B. The intersection of the budget constraint BE' with the modified contract curve defines the equilibrium.

The quantitative significance of loss aversion on real interest rates and savings is indicated in lines 6 and 7 for the third case considered in Table 3. With the standard deviation of up to 6%, the constraint is not binding, so the real interest rates and savings are the same as in the benchmark case. But the effect of loss aversion becomes apparent when the standard deviation increases to 12%: this generates a substantial increase in the EM savings and a marked fall in the global interest rates. As a consequence, the US deficit rises by 1% of GDP as a 0.7% fall of the real interest rates encourages US consumption.

Table 4 indicates the parameter values necessary to replicate the equilibrium with loss aversion by changing time preferences and state probability assessment on the part of EM. When $\sigma = 12\%$, for example, $\beta' = 1.03\beta$ and $\pi' = 0.98\pi$ will generate the same equilibrium allocation as under loss aversion.

σ	Loss aversion constraint	β'/β	π'/π
3%	Not binding	1	1
6%	Not binding	1	1
12%	Binding	1.03	0.98
18%	Binding	1.07	0.97

Table 4. Loss aversion, less time preferences and more pessimism.

4.2. Loss aversion with incomplete markets

Results in the section above show how loss aversion can significantly increase savings and reduce the world interest rate, even though both countries share risk in the second period. But global financial markets are notoriously incomplete, as emphasised by Wolf (2005) and Griffith-Jones and Shiller (2006). What happens if we assume that EMs can not swap their risky debt for US bonds but can accumulate the latter through current account surpluses? Results for this bond-only case are summarised in the propositions below, and the quantitative significance indicated by numerical examples.

Proposition 4. For $\sigma \le g$, the equilibrium real interest rates and consumption allocations are the same for bonds only without loss aversion (see Section 3.2.)
But for $\sigma > g$, the constraint $C_2^*(2) \ge C_1^*$ binds, and the equilibrium real interest rate is

$$1 + r = \frac{-\psi + \sqrt{\psi^2 + 4\beta Y_1 Y_2 /(1+\beta)^2}}{2\beta Y_1 /(1+\beta)} \tag{14}$$

where $\psi = \beta Y_1 /(1+\beta) + Y_1 - Y_2^*(2) - Y_2 /(1+\beta)$.

The consumption allocation for EM is given by

$$C_2^*(1) = Y_2^*(1) + (1+r)(Y_1 - Y_2^*(2))/(2+r) \tag{15}$$

$$C_2^*(2) = C_1^* = [(1+r)Y_1 + Y_2^*(2)]/(2+r) \tag{16}$$

and the consumption allocation for US can be obtained simply by using the market clearing conditions.

Proof: For $\sigma \le g$, one can show that $C_2^*(2) \ge C_1^*$, so real interest rates and consumption allocation in Section 3.2 still constitute the equilibrium solution. For $\sigma > g$, however, solutions in Section 3.2 violate the constraint $C_2^*(2) \ge C_1^*$. Imposing binding constraint yields the optimal consumption for EM as in (15) and (16). The optimal consumption for US, derived in the same way as in Section 3.2, gives

$$C_1 = \frac{1}{1+\beta}\left(Y_1 + \frac{Y_2}{1+r}\right) \equiv \frac{W}{1+\beta} \tag{17}$$

$$C_2(1) = C_2(2) = \frac{\beta(1+r)W}{1+\beta} \tag{18}$$

Using market clearing condition $C_1 + C_1^* = 2Y_1$ one arrives at the equilibrium real interest rates represented by (14). Using (14), one can back out the equilibrium consumption for both US and EM.

Two implications of the above proposition are worth noting. First that, *with bonds only, the loss aversion constraint $C_2^*(2) = C_1^*$ binds for a smaller σ than is the case when Arrow securities can be traded.* This is because the removal of state-contingent securities means that risk can not be shared at a global level, so EM has to self-insure by increasing savings even for a moderate σ. Second that, when the loss aversion constraint is binding*, the global real interest rate is determined independently of state probabilities.*

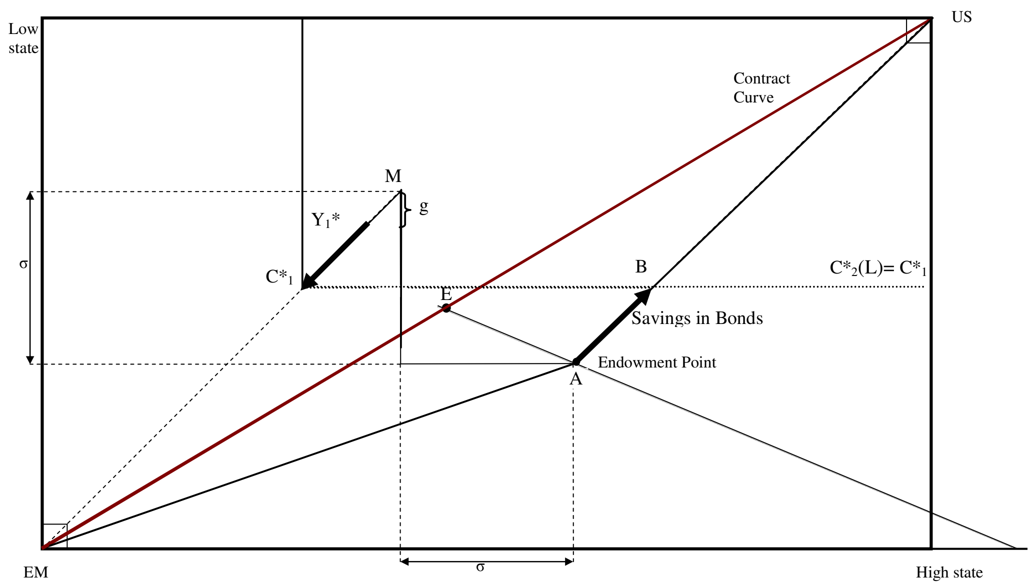

Figure 5. Loss Aversion and Precautionary Saving

In state space form, equilibrium with fear and market failure is shown in Figure 5. Note that due to incomplete markets, there is no asset swap of GDP-bonds: instead, to acquire US bonds, EM is forced to self-insure by saving in period 1. The effective endowment position in period 2 shifts from A to B where the vector AB includes the interest rate on savings. How this interest rate is determined can be seen in the following Fisher diagram.

As before, the horizontal axis measures endowments and consumption in period 1, and the vertical outcomes in period 2. Point A describes the income in both periods for US and the hyperbola AF represents US offer curve[16]. (Point A also indicates first period income and *average* second period endowments for EM.) For any given

[16] The parametric representations of the US offer curve is given by the US inter-temporal budget constraint and the proportionality condition, $C_2 / C_1 = (1+r)\beta$, implied by its first order conditions. Replacing the real interest rates in one of the equations using the other gives the US offer curve.

interest rate, the intersection of the appropriate US budget constraint AA' and the offer curve AF determines the optimal inter-temporal consumption allocation of the US (at point A') and the US current account deficit.

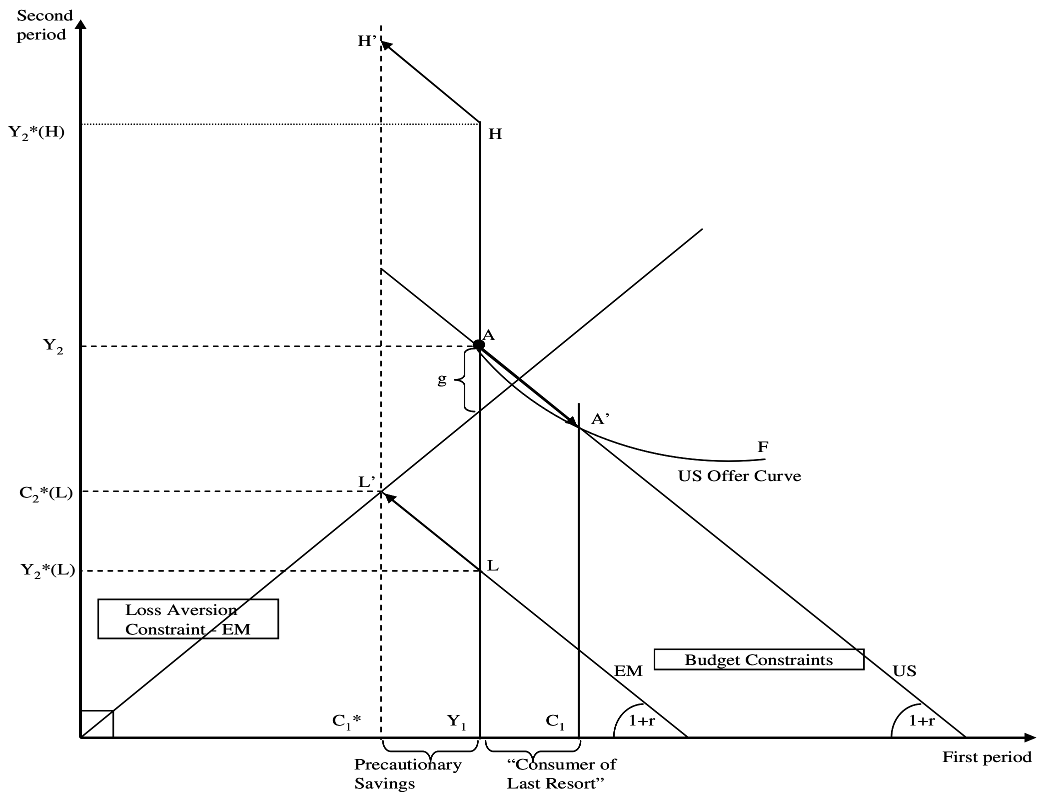

Figure 6: Global Equilibrium: Precautionary Saving and "the consumer of last resort"

Turning to the EM, when the constraint is binding its inter-temporal budget constraint, $C_1^* + C_2^*(L)/(1+r) = Y_1 + Y_2^*(L)/(1+r)$, is represented by the downward sloping line passing through low state endowment L. To satisfy the constraint, consumption in the first period and in the low state in the second period must lie on the 45-degree line OC. The intersection of the budget line LL' and this 45-degree line determines the EM precautionary savings, indicated by the horizontal distance $C_1^* Y_1$. As σ increases, and point L moves downwards, precautionary savings will go up.

How is the world interest rate to be determined? For markets to clear in period 1, the real interest rate has to fall sufficiently so that extra consumption by the US balances precautionary savings by the emerging markets. In Martin Wolf's words, the US has to act as the global 'consumer of last resort' (Wolf, 2006). Diagrammatically, the real interest rate must be chosen such that vector of excess consumption AA' is equal and opposite to the precautionary savings vector LL', as in Figure 6. It is clear from the figure that an increase in σ would result in an increase in the EM's savings. To ensure that this is matched by the US deficit, the budget line AA' has to rotate anti-clock-wise, reducing real interest rates.

Three observations are clear from the Figure. First, that as L' is on a budget line which lies below the usual Fisherian inter-temporal budget constraint, *loss aversion can apparently generate outcomes observationally equivalent to the lack of capitalisation postulated by Caballero et al (2006) and the contrarian view of Cooper (2005).*

The second that *the predictions for savings and global interest rates in period 1 do not depend on the state probabilities*. Figure 6 illustrates the global equilibrium for the case where high and low states are equi-probable: so the US trading vector AA' is balanced by the equally weighted EM's trading vectors LL' and HH'. Consequently, when high state is realised in period 2, this model predicts a massive increase in the EM's state consumption (given by point H'). But this unrealistic prediction can easily be modified without changing savings behaviour. Consider for example, the case of asymmetric shocks where there is low probability of a large negative shock and a high probability of a small positive shock, see Jeanne and Ranciere (2006).

To keep the mean-preserving feature of the EM's second period state endowments, requires $\pi(Y_2+\sigma_H)+(1-\pi)(Y_2-\sigma_L)=Y_2$ or $\sigma_H=\frac{1-\pi}{\pi}\sigma_L$, where σ_H is the shock in the high state and σ_L that in the low state. By fixing σ_L at the same level as that in Figure 6, one can choose π close to 1 to make σ_H arbitrarily small. This would yield the same equilibrium savings as drawn in Figure 6, but reduce EM's high state consumption substantially. This is because savings and the interest rate do not depend on how likely the low state is but on how bad it is.

The third observation is that, given expectations of a large negative shock, *equilibrium real interest rates can be negative*. In terms of the figure, this will occur when the point A' on the US offer curve required to match these savings is sufficiently far to the right that the budget line has an absolute slope less than unity.

The algebraic condition for negative real rates is as follows:

Proposition 5. Given the endowment structure specified in Table 2, the real interest rate $r \leq 0$ for $\sigma \geq (2-2\beta)/(1+\beta)+[2/(1+\beta)+1]g$.

Proof: From (14), imposing the condition $r \leq 0$, one obtains the parameter restriction given in the above proposition.

This is illustrated numerically in the last two lines of Table 3, where for σ=12% savings reaches 4.6% and the equilibrium real interest rate fall to -4.3%[17].

The relationship between real interest rates and risk for parameters of our benchmark model is illustrated in more detail in Figure 7 where the horizontal axis measures the negative shock to EM's period 2 endowment and the equilibrium real interest rates is plotted on the vertical axis. When the loss aversion constraint is not binding real interest rates decrease very slowly with increasing σ; but when the loss aversion constraint is binding the real interest rates fall sharply as risk increases. From Proposition 5, the critical level of σ beyond which the real interest turns negative turns out to be about 7.5% for the parameters used here.

[17] Note that in their paper on the optimal level of international reserves for emerging market countries, Jeanne and Ranciere (2005) assume a crisis output cost of 10% in their benchmark calibration.

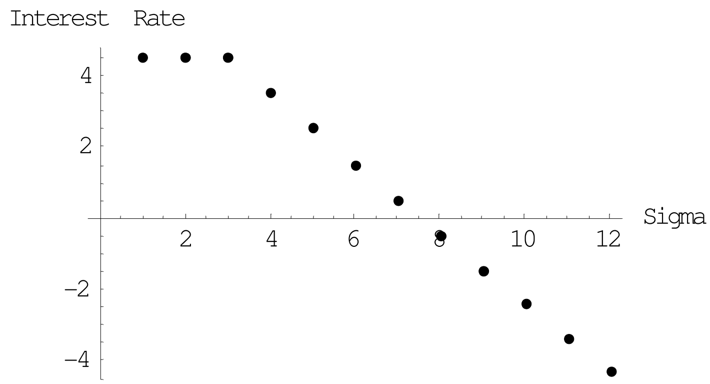

Figure 7. Real interest rates and risk: numerical results.

Possible ramifications of negative real interest rates are discussed below. Here we summarise the results of the earlier calibrations in a new table, where the effect of fear is captured by moving from orthodox preferences to loss aversion and that of market failure by restricting the set of Arrow securities. As can be seen from Column 1, fear does cause some increase in global imbalances but not a great deal; similarly from row 1 we see that market failure also increases global imbalances, but only marginally. It is when fear and market failure combine that global imbalances become significant and real interest rates can turn negative.

		Arrow-Debreu	Incomplete Markets
Orthodox preferences	**Δ deficit/GDP** *Δ interest rate*	**+0.2** *-0.3*	**+0.3** *-0.6*
Loss Aversion in EM	**Δ deficit/GDP** *Δ interest rate*	**+1.2** *-1.4*	**+4.6** *-8.8*

Table 4. The effect of increasing risk (from benchmark of σ = 3 to σ=12)

Note: For Jeanne and Ranciere (2006) **σ** of 10% might lead to imbalances of about 5%.

5. Strategic considerations

All the calculations reported above assume competitive equilibrium even when the set of assets is incomplete. But, as Dooley and Garber (2005) point out, the big players in asset markets are governments who can manipulate supply. Furthermore, Meissner and Taylor have shown how Britain in the years 1870–1913 and US in years 1981 – 2003 have been able to enjoy a "privilege" in the form of higher yields earned on external assets than paid on external liabilities – worth about 0.5% of GDP per annum in both cases. Could this, in the terminology of Hausmann and Sturzenegger (2005), be the "dark matter" which allows the US to sustain substantial portfolio imbalance? Maybe so, but Meissner and Taylor warn that such monopoly power is a fading asset: the privilege is much higher in earlier years than later.[18]

Could one modify the competitive equilibrium by allowing for monopoly power on the part of the US? Instead of supplying safe asset on a competitive basis, US could, for example, select the utility maximising point on the demand for safe asset from the EM: or could it act as a dynamic monopolist?[19] As indicated by Table below this might generate outcomes between limit cases (of complete markets and no insurance) reported in the paper.

	Arrow-Debreu	**Market power**	**Self-insurance**
Standard preferences	Low savings; Fair Insurance	More saving; Overpriced insurance	High Precautionary Savings; No insurance
Loss aversion in EM	Same as above, unless binding	High Precautionary Savings; Overpriced insurance	High Precautionary Savings; No insurance

Table 7. General Equilibrium solutions: Is there a place for strategic analysis?

6. Sustainability: a comparison

It may be interesting to compare what we get from a general equilibrium approach with results reported in a recent IMF study of the optimal reserves by Jeanne and Ranciere (2005). For an emerging market economy facing a low spread in capital markets, the risk of a 10% fall in output should lead to reserve holdings of 9.37% of GDP, see discussion of Table 3 in their paper. Note that, as all these reserves will be

[18]The gradual disappearance of the privilege is examined in Thamotheram, 2006.
[19] Supplying dollars at high prices as the RoW accumulates reserves, with a dollar devaluation when reserve stock reaches equilibrium, see Section 7.2 below.

used to maintain consumption when there is a shock and they are all reconstituted one period later, it is as if such a shock is associated with a corresponding *savings rate* of nine and a half percent of GDP over the post crisis period of reserve build up. As there is no insurance in their model, this is to be compared with our bonds-only case, where the build-up of reserve assets *precedes* the crisis. For a shock with a downside of 12% our figure for savings is about four and a half percent. While this is only about half as much as for Jeanne and Ranciere (2006), this may be because we allow for consumption smoothing across the two periods while their static simplification rules this out.[20]

Two observations may be made – over the period of time that reserves are built up, and over the implications for sustainability. As a preliminary, note that the actual reserve holdings by China greatly exceed the savings figures just discussed: from around 16% of GDP in 2000 they almost doubled to reach 29% in 2003, Jeanne and Ranciere (2006, Table 1). This suggests that treating the issue in a two period context (as the IMF study and we do) is too restrictive. The level of reserves may be built up over a period of two or three years – and it can be expanded by assets swaps as well as external surpluses, as the case with insurance has shown.

The second observation is that the reserve build-up is essentially a *transitional* phenomenon: once reserves have reached their desired level, there is no need for high precautionary savings[21]. This has profound implications: high savings, low interest rate outcomes we have studied are not to be thought of as steady-state equilibria, but as temporary phenomena. Putting it more bluntly, the precautionary approach implies that the current pattern of imbalances is not sustainable. What this might mean for global equilibrium is considered in Section 7.2.

7. The possibility of Keynesian equilibria

[20] For countries facing high interest rates, however, the optimal reserve holding is calculated to be only about 1½% of GDP – with a correspondingly lower saving rate, Jeanne and Ranciere (2006, Table 3).

[21] We can show this in the GE context by changing the initial holding of bonds by the RoW, which play the same role as reserves as in the analysis of Jeanne and Ranciere (2006).

7.1 The Liquidity Trap

No matter that EM saving rises sharply as perceived risk increases, markets will clear so long as the real interest rate is free to adjust. That is the message of the calculations at the end of Section 4: and it seems to suggest that the model we propose, like that of Caballero et al., is one of full employment equilibrium, loss aversion or no.

It was found, however, that market-clearing interest rates have to be *negative* for substantial risk ($\sigma > 7.5\%$). What if there is a zero lower bound on the real interest rate? This will imply that the US deficit is less than high savings in the EM in these circumstances: in other words, global demand will fall short of global supply at full employment levels of income.

When might such a bound be relevant? Consider a world with fixed nominal prices and a zero lower bound on the *nominal* interest rate: in such a world, real rates can be lowered by cutting nominal rates, but they cannot go below zero. (Nor would adding price flexibility help, unless prices are expected to rise.) The case of Japan, where the collapse of the Nikkei in the early 1990s was followed by a decade or more of inadequate demand with sticky prices and near zero nominal rates, may serve to illustrate.

If one was to impose an exogenous zero bound on the real rates, how is the model to be solved? One will have to make assumptions of what happens when markets do not clear: that supply contracts until global demand and supply balance, for example. Assuming that EM savings were proportional to its first period income, then a contraction of EM income sufficient to cut EM savings to match the US full employment deficit would equate demand and supply. This is, in fact, something like what happened after the East Asian crisis when countries in the region went into sharp recession and the US acted as the 'consumer of last resort'. But if income in both countries can be treated as endogenous, there will be many other equilibria, as there are two variables and only one constraint[22].

[22] It may be tempting, for this reason to aggregate across the two regions and treat the world as a closed economy.

Rather than pursuing this thought experiment much further, it is better to acknowledge that one is re-examining issues at the heart of the debate between Keynes and the Classics. Faced with a rise of savings, Classical economists argued that interest rates would fall as needed to equate savings and investment (and preserve full employment). Keynes objected that interest rates would be subject to a lower bound (set by the Liquidity Trap) and, for this reason, income would become endogenous, falling until savings matched investment. The Japanese experience has led to a resurgence of interest in Keynesian equilibria, most notably in the 1998 Brookings Paper by Paul Krugman subtitled "Japan's Slump and the Return of the Liquidity Trap".

7.2. A 'Sudden Stop'?

Given robust expectations of growth, current real interest rates are surprisingly low; but the world is not in a liquidity trap. Nevertheless, the pattern of global imbalances has given economists cause for concern. Does the global model sustain such concern or not? First, we conclude that a pattern of global imbalances where high savings in the EM is matched by corresponding US deficits is essentially a transitional phenomenon. So some adjustment will have to come.

When reserve positions are adequate, there will be no need for additional precautionary saving, and EM should consume more and the US less. In addition, however, *relative prices may need to adjust*. This is spelled out in detail in Obstfeld and Rogoff (2005), for example, who argue that the price of US non-traded goods will have to fall sharply relative to EM non-traded goods, and the relative price of US traded goods will also have to fall. Given the objective of keeping the aggregate price indices constant in each block, they calculate that this translates into a decline of about 30% in the dollar. In their view, moreover, the perception that the situation is not sustainable and that adjustment requires a fall in the dollar leaves the US vulnerable to a 'Sudden Stop' in capital flows.

No adjustment of relative prices is necessary in our one good model: but what if, nonetheless, there a 'Sudden Stop' were to occur constraining the US to balance its current account? This would of course prevent the US from acting as 'consumer of last resort', and require the EM to achieve balance on its own. If there is a precautionary demand for savings outside the US – and particularly if there is limited access to insurance markets – an excess supply of global savings will emerge. But, in a world of low inflation and low nominal rates, the Classical argument that the implied shortage of global demand can be remedied by an appropriate lowering of interest rates lacks conviction. We have seen that a Liquidity Trap could, in principle, prevent this adjustment even where the US is free to act as 'consumer of last resort': how can it be relied to work in circumstances when the US consumption is checked by financial panic?

8. Conclusion

A model of global equilibrium where countries outside the US face higher risk than the US itself can lead to current account surpluses in the EM. If it is driven by Loss Aversion, such precautionary savings can cause substantial 'global imbalances', particularly if there is an inefficient supply of global insurance. In principle, this simply requires lower real interest rates to ensure that aggregate demand equals supply at the global level (though the required real interest may turn out to be negative). A situation with low interest rates and high savings outside the US thus appears to be an efficient global equilibrium: but is it sustainable?

A precautionary savings glut appears to us to be a temporary phenomenon, destined for correction as and when adequate reserve levels are achieved. In a realistic setting with differentiated traded and non-traded goods, this correction will also require a substantial change in relative prices. So expectations of adjustment may lead to a pre-emptive 'Sudden Stop' in capital flows to the US, as Obstfeld and Rogoff have suggested.

If the process of correction is triggered by panic, could it not lead to the inefficient outcomes that concern macroeconomists such as Eichengreen and Park, Roubini and Setser, and Martin Wolf? The unprecedented savings levels recorded in East Asia since 1997/8 financial crises and the prolonged failure of Japan to escape from a Liquidity Trap would then appear as early warning signals: and the failure to effect a smooth transfer after the first World War, leading as it did to a Liquidity Trap and the emergence of Keynesian under-employment economics, as a precedent that should not be ignored. Blithe trust in market forces may be misplaced. When precautionary savings is combined with financial panic, history offers no guarantee of full employment.

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Appendices

Appendix A. Proof of Proposition 1

Note that the modification of Foreign preferences only affects the partial equilibrium allocation for the Foreign country. To solve for the optimal consumptions for the Foreign country, we first replace C_1^* in (13) and (12) using budget constraint (14) to form the following Lagrangean:

$$L = \ln(W^* - q^{LA}(1)C_2^*(1) - q^{LA}(2)C_2^*(2)) + \beta[\pi \ln(C_2^*(1)) + (1-\pi)\ln(C_2^*(2))]$$
$$+ \lambda_1[C_2^*(1) - W^* + q^{LA}(1)C_2^*(1) + q^{LA}(2)C_2^*(2)] + \lambda_2[C_2^*(1) - W^* + q^{LA}(1)C_2^*(1) + q^{LA}(2)C_2^*(2)]$$

The first order conditions become

$$-\frac{q^{LA}(1)}{C_1^*} + \frac{\beta\pi}{C_2^*(1)} + \lambda_1[1+q^{LA}(1)] + \lambda_2 q^{LA}(1) = 0 \quad \text{(A1)}$$

$$-\frac{q^{LA}(2)}{C_1^*} + \frac{\beta(1-\pi)}{C_2^*(2)} + \lambda_1 q^{LA}(2) + \lambda_2[1+q^{LA}(2)] = 0 \quad \text{(A2)}$$

$$\lambda_1(C_2^*(1) - C_1^*) = 0,\ \lambda_1 \geq 0,\ C_2^*(1) \geq C_1^* \quad \text{(A3)}$$

$$\lambda_2(C_2^*(2) - C_1^*) = 0,\ \lambda_2 \geq 0,\ C_2^*(2) \geq C_1^* \quad \text{(A4)}$$

(A3) and (A4) are complementary slackness conditions.

Given $Y_2^*(1) > Y_2^*(2)$, there are only three possible cases: (i) $\lambda_1 = \lambda_2 = 0$, (ii) $\lambda_1 = 0$ and $\lambda_2 > 0$, and (iii) $\lambda_1 > 0$ and $\lambda_2 > 0$.

For $\lambda_1 = \lambda_2 = 0$, (A1), (A2) and budget constraint (14) imply

$$C_1^* = W^*/(1+\beta). \quad \text{(A5)}$$

$$C_2^*(1) = \beta\pi C_1^* / q^{LA}(1) \quad \text{(A6)}$$

$$C_2^*(2) = \beta(1-\pi)C_1^* / q^{LA}(2) \quad \text{(A7)}$$

The equilibrium conditions ensure that $q^{LA}(1) = q(1)$ and $q^{LA}(2) = q(2)$ (where $q(1)$ and $q(2)$ are given by (6) and (7)).

Using constraints $C_2^*(1) \geq C_1^*$ and $C_2^*(2) \geq C_1^*$, one arrives at $Y_2^W(1) \geq Y_1^W$ and $Y_2^W(1) \geq Y_1^W$, or $2g - \sigma \geq 0$ for endowments given in Table 1. As $q^{LA}(1) = q(1)$ and $q^{LA}(2) = q(2)$, the general equilibrium allocation will be the same as in Section 2.1.

Appendix B. Proof of Proposition 2

Consider the second case outlined above, namely, $\lambda_1 = 0$ and $\lambda_2 > 0$. The first order conditions become

$$-\frac{q^{LA}(1)}{C_1^*}+\frac{\beta\pi}{C_2^*(1)}+\lambda_2 q^{LA}(1)=0 \quad \text{(B1)}$$

$$-\frac{q^{LA}(2)}{C_1^*}+\frac{\beta(1-\pi)}{C_2^*(2)}+\lambda_2[1+q^{LA}(2)]=0 \quad \text{(B2)}$$

$$\lambda_1=0,\ \ C_2^*(1)\geq C_1^* \quad \text{(B3)}$$

$$C_2^*(2)-C_1^*=0, \lambda_2>0, \quad \text{(B4)}$$

Solving them yields

$$C_1^*=C_2^*(2)=\frac{1+\beta(1-\pi)}{(1+\beta)(1+q^{LA}(2))}W^* \quad \text{(B5)}$$

$$C_2^*(1)=\frac{\beta}{1+\beta}\frac{\pi}{q^{LA}(1)}W^* \quad \text{(B6)}$$

$$\lambda_2=\frac{1+\beta}{W^*}\frac{q^{LA}(2)-\beta(1-\pi)}{1+\beta(1-\pi)} \quad \text{(B7)}$$

To ensure (B5) – (B7) constitute optimal solutions for the Foreign country, we need to impose the restrictions on the Lagrange multipliers as those given at the beginning. Condition $\lambda_1=0$ implies $C_2^*(1)\geq C_1^*$. From (B5) and (B6), this requires

$$\beta\pi(1+q^{LA}(2))\geq[1+\beta(1-\pi)]q^{LA}(1) \quad \text{(B8)}$$

From (B7), condition $\lambda_2>0$ requires

$$q^{LA}(2)>\beta(1-\pi) \quad \text{(B9)}$$

To solve for the equilibrium prices, we impose the following market clearing conditions:

$$C_2(1)+C_2^*(1)=Y_2^W(1) \quad \text{(B10)}$$

$$C_2(2)+C_2^*(2)=Y_2^W(2) \quad \text{(B11)}$$

Condition (B10) implies

$$q^{LA}(1)=\frac{\beta\pi}{1+\beta(1-\pi)}\frac{Y_1^W+q^{LA}(2)Y_2^W(2)}{Y_2^W(1)} \quad \text{(B12)}$$

This Arrow price relationship is exactly the same as the one in complete markets without loss aversion.

Replacing $q^{LA}(1)$ in the state price relationship implied by (B11) yields the following quadratic equation for $q^{LA}(2)$

$$(d/q(2)-b)[q^{LA}(2)]^2+\Delta q^{LA}(2)+a\beta(1-\pi)-d=0 \quad \text{(B13)}$$

where

$$a=\left(\frac{1}{2}+\frac{\beta\pi}{1+\beta(1-\pi)}\frac{Y_2^*(1)}{Y_2^W(1)}\right)Y_1^W$$

$$b=\left(\frac{Y_2^*(2)}{Y_2^W(2)}+\frac{\beta\pi}{1+\beta(1-\pi)}\frac{Y_2^*(1)}{Y_2^W(1)}\right)Y_2^W(2)$$

$$d=(1+\beta)\beta(1-\pi)Y_1^W$$

$$\Delta=d/q(2)+b\beta(1-\pi)-a-d$$

Since $d/q(2)-b>0$ and $a\beta(1-\pi)-d<0$, (B13) has a positive and a negative roots. Choosing the positive solution gives

$$q^{LA}(2)=\frac{-\Delta+\sqrt{\Delta^2-4(d/q(2)-b)(a\beta(1-\pi)-d)}}{2(d/q(2)-b)} \qquad \text{(B14)}$$

Applying (B9) to (B14) yields

$Y_2^W(2)<Y_1^W$

or

$$2g-\sigma<0 \qquad \text{(B15)}$$

With (B15) and assumptions made in Table 1 ($Y_2^W(1)>Y_1^W$), (B8) is satisfied. So (B15) is the parameter restriction used in Proposition 2.

Rearranging (B13), one can show

$$(a+bq^{LA}(2))(q^{LA}(2)-\beta(1-\pi))=d(1+q^{LA}(2))(q^{LA}(2)/q(2)-1) \qquad \text{(B16)}$$

As a, b, d and $q^{LA}(2)$ are all positive, with $q^{LA}(2)-\beta(1-\pi)>0$ implied by (B15), (B16) can hold if and only if

$q^{LA}(2)/q(2)-1>0$

So $q^{LA}(2)>q(2)$.

Since (B12) is the Arrow price relationship in complete markets without loss aversion, so if $q^{LA}(2)=q(2)$, (B12) must imply $q^{LA}(1)=q(1)$. As $q^{LA}(1)$ varies positively with $q^{LA}(2)$ in (B12), $q^{LA}(2)>q(2)$ implies $q^{LA}(1)>q(1)$. To see how relative prices $q^{LA}(2)/q^{LA}(1)$ must increase in the presence of loss aversion, we rearrange (B12) to yield

$$\frac{1+\beta(1-\pi)}{\beta\pi}Y_2^W(1)=\frac{Y_1^W}{q^{LA}(1)}+\frac{q^{LA}(2)}{q^{LA}(1)}Y_2^W(2)$$

As $q^{LA}(1)>q(1)$, the above equation implies $q^{LA}(2)/q^{LA}(1)>q(2)/q(1)$.

The effect of loss aversion on the equilibrium real interest rates is straightforward to gauge. Because $q^{LA}(2)>q(2)$ and $q^{LA}(1)>q(1)$, so

$$1+r^{LA}=\frac{1}{q^{LA}(1)+q^{LA}(2)}<1+r=\frac{1}{q(1)+q(2)}.$$

To show (5) in Proposition 2, note that from (B5), (B6), (4)—(7), one has

$$\frac{C_2^*(2,LA)}{C_2^*(1,LA)}/\frac{C_2^*(2)}{C_2^*(1)}=\frac{1+\beta(1-\pi)}{\beta\pi}\frac{q^{LA}(1)}{1+q^{LA}(2)}\frac{q(2)}{q(1)}$$

Replacing the relative prices $q^{LA}(2)/q^{LA}(1)$ using (B12), one can show that the right hand side of the above equation is strictly greater than 1.

Appendix C. Proof of Proposition 3.

With parameters $\{\beta', \pi'\}$ for the Foreign country, the optimal consumption without loss aversion gives arise the following set of first order conditions:

$$C_1^* = W^* / (1+\beta') \, . \tag{C1}$$

$$C_2^*(1) = \beta' \pi' W^* / [(1+\beta') q^{LA}(1)] \tag{C2}$$

$$C_2^*(2) = \beta' (1-\pi') W^* / [(1+\beta') q^{LA}(2)] \tag{C3}$$

Equating (C1) and (B5) gives

$$\beta' = \frac{(1+\beta) q^{LA}(2) + \beta\pi}{1+\beta(1-\pi)} \tag{C4}$$

Equating (C3) and (B7) yields

$$\pi' = \frac{\beta\pi(1+q^{LA}(2))}{(1+\beta) q^{LA}(2) + \beta\pi} \tag{C5}$$

As $q^{LA}(2) > \beta(1-\pi)$, one can easily show that $\beta' > \beta$ and $\pi' < \pi$.