SHOCKS AND SHOCK ABSORBERS: THE INTERNATIONAL PROPAGATION OF EQUITY MARKET SHOCKS AND THE DESIGN OF APPROPRIATE POLICY RESPONSES[1]

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Abstract: Equity prices are major sources of shocks to the world economy and channels for propagation of these shocks. We seek to calibrate macroeconomic effects of falls in share prices and assess appropriate policy responses, using the National Institute Global Econometric Model NiGEM. Based on estimated relationships, falls in US equity prices have significant impacts on global activity; potential for liquidity traps suggest a need for complementary monetary and fiscal policy easing. However, the latter boosts long-term real interest rates and hence moderates one of the automatic shock absorbers provided by the market mechanism.

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Introduction

Equity prices and equity markets are major sources of shocks to the world economy and major channels for the propagation of these shocks. In this paper we seek to calibrate their effects, and assess what policy responses can best absorb them. We first briefly discuss the evidence for the effects of equity prices on real economic activity. We then outline our framework for analysis, which is the National Institute Global Econometric Model NiGEM. Besides its structure per se, outturns in terms of the residuals on forward looking structural equations for equity prices, consumption, investment and real income also provide relevant background. We then look at key features of the recent bear market, viewed in the light of the last one in 1972-5. The equity premium had shrunk to historically low levels in 1999, suggesting overvaluation; also there was a very high level of correlation between markets during the 2000-2 bear market. We then assess the implications of equity price falls comparable to those seen in 2000-2 in the context of NiGEM, presenting a range of simulations on the model giving a view of the macroeconomic impact of recent equity market falls, viewed in the context of the high degree of correlation, and also the effect of differing policy responses.

1 The Macroeconomic Importance of Equity Markets

There is a significant literature investigating the impact of wealth – itself driven partly by share prices - on consumption. A recent example is Davis and Palumbo's (2001) study of the US consumption function, which attempts to determine whether changes in wealth affect the growth rate of consumer spending. They examined quarterly aggregate US data from 1960 to 2000 and modelled long-run relationships to investigate whether (logged) consumption, income and wealth share a common trend. They found that there is a statistically significant long run wealth effect on consumer spending. Ludvigsen and Steindel (1999) also examined wealth effects in a loglinear long-run consumption relationship and found a statistically significant wealth and income effect. They also showed that these variables share a common trend, using quarterly US data. Further utilising the approach adopted in that paper, Lettau and

Ludvigsen (2001) went on to also find that deviations from this common trend are a powerful predictor of excess returns on aggregate stock market indexes for US data.

Outside the US, Barrell, Byrne and Dury (2003) found evidence of an effect of wealth and income on consumption in the European economies, and tested in a panel context for differences between European countries. They found that it is possible to show that France, Germany, the Netherlands and Austria have similar consumption behaviour with significant wealth effects. Byrne and Davis (2003a) analysed the impact of disaggregated wealth on consumption for G-7 countries, and found that, contrary to earlier empirical work, illiquid financial wealth, (equities, bonds, life insurance and pension assets less mortgage debt) scaled by personal disposable income (PDI), tends to be a more significant long-run determinant of consumption than liquid financial wealth (deposits and money market instruments less other debt) across the G-7. They suggested that this pattern reflects a shift from liquidity constrained to life cycle behaviour following financial liberalisation, and also a more disaggregated pattern of wealth holding. Results were robust in SURE analysis, tested in a nested manner, using varying definitions of liquid assets and using non-property income instead of personal disposable income.

Table 1 shows the ratio of wealth to personal income in the major economies, used in the Barrell et al work cited above, and also gives net illiquid wealth (securities, pensions and mortgage debt) used in Byrne and Davis. Net illiquid assets are particularly high in the US, UK and Italy, and particularly low in Germany and Japan. As regards changes in wealth which could impact on consumption, the table shows that falls in the UK and US over 1999-2001 were 100% of PDI, and are likely to have been much greater by end-2002. Falls in France and Italy were around half those in the UK and US, while the data showed relatively small declines in Germany, Canada and Japan. The penultimate line shows direct equity holdings[4], while the bottom line, from Byrne and Davis (2003b), makes a correction for institutional holdings on behalf of households. It shows that portfolio shares of equity allowing for indirect holdings are quite comparable across the G-7, with the outliers being Japan and to a lesser extent Germany and Italy. The ratio of direct to total equity holdings is an indicator of the immediate visibility of equity price changes to consumers, and might be expected to affect the speed of response to a change in equity prices.

Turning to investment, as shown in IMF (2003), declines in investment often have a substantial impact on GDP growth after equity price falls, and falls in investment were sizeable in the recent bear market, partly linked to the high level of corporate debt and reliance on external finance generally in the bull period. Some international analysis of single-equation investment functions suggests a marked impact of equity prices, via the valuation ratio (Tobin's Q) or the debt-equity ratio. For example, work on the G-7 by Ashworth and Davis (2001) suggests a broad range of financial variables, consistent with the valuation ratio, financial accelerator and credit channel approaches, are relevant determinants of business fixed investment over and above those variables normally included in traditional macroeconomic investment functions. Particularly notable was a widespread effect of the debt-equity ratio, implying that the financial accelerator or net worth channel, linked to credit rationing and "precautionary" variations in credit demand is of widespread importance at a macro level. The results for the UK, Germany and France were particularly close in magnitude, despite the different financing structures in those countries. The credit channel, as indicated by the ratio of loans to total debt, was less widespread, featuring only in the US and Japan where non-bank sources of funds are relatively well developed. The results indicated a wider incidence of these financial effects on investment than the existing literature, focused as it is on the US, would otherwise indicate. A complementary panel study using firm level data

[4] Note from the memo line that the direct holdings of equity are largest in France, Canada and the US and lowest in Germany and Japan. The large difference between this figure and illiquid financial wealth is largely a consequence of the importance of institutional investors, albeit also in some countries reflecting bond holdings.

by Catao reported in IMF (2003) found a more marked effect of the debt/equity ratio on investment in the euro area than the US, notably during bear markets. This result was attributed to greater bank dependence of Continental European firms than American firms.

2 Modelling the Impact of Equity Prices

Over the last 15 years, NIESR has developed the global macro model NiGEM for use in policy analysis[5]. NiGEM is an estimated model, which uses a 'New-Keynesian' framework in that agents are presumed to be forward-looking, but nominal rigidities slow the process of adjustment to external events. All countries in the OECD are modelled separately. All economies are linked through the effects of trade and competitiveness. There are also links between countries in their financial markets via the structure and composition of wealth, emphasising the role and origin of foreign assets and liabilities. There are forward-looking wages, consumption, and exchange rates, while long-term interest rates are the forward convolution of short-term interest rates. The model has complete demand and supply sides and there is an extensive monetary and financial sector. NiGEM contains expectations and uses the Extended Path Method to obtain values for the future and current expectations and iterate along solution paths

International propagation of shocks to US equity prices in the model relies on two main sets of channels. Those due to model structure, notably trade and the effects of financial asset prices on consumption, propagate the shock through US demand for foreign output or through the impact on the demand of foreign residents for all output. We detail aspects of the underlying equations below. In addition policy responses can be part of the propagation of the shock. If both demand and inflation in the US fall then the Federal Reserve can be expected to cut short-term interest rates. This will help to absorb the shock, but it will also cause the dollar to fall. The depreciation of the dollar improves US competitiveness and also helps to absorb the shock in the US. It will raise US exports and reduce imports as compared to where they would otherwise have been without the improvement in competitiveness. The improvement in competitiveness must be matched elsewhere by deterioration in other countries' competitiveness, and this also propagates the shock to other countries.

Shocks are not only absorbed by the operation of policy rules, but also by the market mechanism. If policy reduces short term interest rates, and is expected to continue to do so, then this causes the long term interest rate to fall, inducing a rise in bond prices that should partly offset the impact on wealth of the fall in equity prices. A decline in US consumption driven by a fall in equity prices and hence wealth raises US saving. The long term real interest rate in our model, which drives the user cost of capital, will fall in the US and elsewhere as a result of changes in the saving and investment balance. This gives a potential boost to investment both in the US and elsewhere and reduces the impact of a rise in the risk premium.

2.1 The Structure of NiGEM

Trade. These equations depend upon demand and relative competitiveness effects, and the latter are defined in similar ways across countries. It is assumed that exporters compete against others who export (X) to the same market via relative prices (RPX), and demand is given by the imports in the markets to which the country has previously exported (S)

$$\Delta X = \lambda[X(-1) - S(-1) + b*RPX] + c1*\Delta X(-1) + c2*\Delta S + \quad + error \qquad (1)$$

while imports (M) depend upon import prices relative to domestic prices (RPM) and on demand (TFE)

$$\Delta M = \lambda[M(-1) - b1*TFE(-1) + b2*RPM] + c1*\Delta M(-1) + c2*\Delta TFE + \quad + error \qquad (2)$$

As exports depend on imports, they will rise together in the model. A similar pattern of linkages is used for trade in services. Both systems of trade equations are 'closed' to ensure that the world balance of trade adds up, at least to its normal degree of accuracy, in any simulation. Of particular relevance for this paper, we can be certain that if US imports fall that

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[5] See NIESR (2003) for a description of the model, and Barrell, Kirsanova and Hurst (2003) for a brief

will be reflected in declines in exports elsewhere in the world. The equations are estimated in equilibrium correction form.

Financial markets Forward looking nominal long rates LR and long real rates have to look T periods forward using expected short-term nominal and real interest rates respectively using

$$(1+LR_t) = \Pi_{j=1,\,T}\,(1+SR_{t+j})^{1/T} \qquad (3)$$

Forward looking exchange rates RX have to look one period forward along the arbitrage relation involving domestic and foreign short term interest rates (SRH and SRF)

$$RX_t = RX_{t+1}\,(1+SRH_t)/(1+SRF_t) \qquad (4)$$

Forward looking equity prices are solved out from the discounted sum of expected discounted profits; where profits are the difference between nominal GDP (GDPN) and labour income (which is the product of wages per unit of labour, W and labour usage, E) after allowing for depreciation of the capital stock (KDEP), divided by the real stock of capital (K). The discount factor is made up of the nominal interest rate, *r*, and the risk premium on equity holding decisions, *rpe*.

$$EQP_t = \Sigma_{i=1}^{\infty}(((GDPN_{t+i} - W_{t+i} * E_{t+i} - KDEP_{t+i})/(K_{t+i}))/((1+r)(1+rpe) \qquad (5)$$

This can be written as an infinite forward recursion that depends only on current profits (∏) and the expected equity price next period, which embeds information on future profits.

$$EQP_t = \prod_t + EQP_{t+1}/\ (1+r)(1+rpe) \qquad (6)$$

The equity price will jump when any of its future determinants changes, and the risk premium is set at its recent value unless reset in the experiment, as it is here.

Wealth and asset accumulation. The wealth and accumulation system allows for flows of saving onto wealth and for revaluations of existing stocks of assets in line with their prices determined as above. In the medium term, personal sector liabilities are assumed to rise in line

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description.

with nominal personal incomes, and if there are no revaluations, gross financial wealth will increase by the nominal value of net private sector saving plus the net increase in nominal liabilities. Revaluations come from three sources, as follows:

(1) Domestic Equity Prices. These revalue the proportion of the domestic share of the portfolio that is held in equities, both quoted and unquoted. We assume that unquoted shares rise in line with quoted shares. Balance of Payments data include an estimate of the equity stock of the domestic production sector held abroad.

(2) Domestic Bond Prices The scope of revaluations to bonds is calculated using information on the maturity structure of government debt. When long rates jump down bond prices jump up. Data are available on the proportion of debt held abroad, and this is used in revaluations.

(3) Foreign Assets and Liabilities There is information on the structure of liabilities to foreigners, and hence when equity and bond prices change, the value of Gross Liabilities also changes. Countries receive revaluations in proportion to their stock of Gross Assets as a share of the world total after factoring out banking sector deposit assets. Hence a change in US (and other) equity prices affects Gross Assets and hence wealth in other countries 'correctly', as do changes in the value of bonds held abroad.

Cross-country differences in the importance of assets as a percent of income, and in the structure of assets, as well as the responsiveness of consumption to them are important factors driving the results below.

Consumption and Personal Income. The consumption relations are based on an Euler equation for a consumer who is not liquidity constrained. The Euler equation embeds an optimising error correction on the long run, preference driven, consumption, income and wealth relationship. The long run parameters have been calibrated from Barrell, Byrne and Dury (2003) and adjustments speeds are estimated in a panel context. We may write the change in consumption, C as depending on the equilibrium correction between consumption, incomes (RPDI) and real net wealth (RNW). Adjustment costs are assumed to be quadratic, and behaviour is forward looking. The coefficient δ on the forward change in consumption is the rate of time preference. The resulting equation with all variables in logs is;

$$\Delta C = \lambda[C(-1) - a*RPDI(-1) - (1-a)*RNW(-1)] + \delta\Delta C(+1) + error \qquad (7)$$

As outlined above, it is assumed that besides being cumulated saving, wealth is affected by financial market activity through equity and bond prices, and if these markets 'expect' something in the future then it will be reflected in prices. News that changes expectations will cause wealth to be revalued, and hence will affect behaviour now. Published data on Net Financial Wealth[6] are used, and the ratios of wealth to income and of wealth to consumption will influence the properties of the model.

Production. For each country there is an underlying CES production function which constitutes the theoretical background for the specification of the factor demand equations for employment and the capital stock, and which form the basis for unit total costs and the measure of capacity utilisation which then feed into the price system. A CES production function that embodies labour augmenting technological progress (denoted λ) with constant returns to scale can be written as:

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-1/\rho} \qquad (8)$$

γ and s are production function scale parameters, and the elasticity of substitution, σ, is given by $1/(1+\rho)$. Variables K and L denote the net capital stock and labour input measured in terms of employee hours. The parameters of the production function vary across countries and w, c and p denote respectively labour costs per head, nominal user costs of capital and the price of

[6] Data for the G7 are discussed in Byrne and Davis (2003b), and are generally available, for instance in OECD sources. For some small countries we have constructed data in consultation with the Central Bank.

value added (at factor cost) and β denotes the mark-up. With long-run constant returns to scale, we obtain log-linear factor demand equations of the form:

$$Ln(L) = [\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)] + \ln(Q) - (1-\sigma)\lambda t - \sigma \ln(w/p) \quad (9)$$

$$Ln(K) = [\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)] + \ln(Q) - \sigma \ln(c/p * (1+rp)) \quad (10)$$

The parameters are used in the construction of an indicator of capacity utilisation, which affects the mark-up of prices over unit total costs. The capital stock adjustment equation depends upon the long run equilibrium capital stock, and the user cost of capital is influenced by the forward-looking real long-term rate, as well as by taxes and by depreciation. The speed of adjustment to equilibrium in the investment/capital stock adjustment equations also depends upon the short-term real interest rate, with this effect being similar across countries. The user cost of capital variable c/p is calculated from data for the past, but individual firms take account of risk on their investments when undertaking projects. The risk premium *rp* can be varied in simulations. If the risk premium is high, then the equity market valuation of the capital equipment will be lower, and hence one can link Tobin's *q* and equity market effects to the level of investment by shifting the risk premium in the cost of capital. We present simulations with and without this feed through to investment in Section 4. Of course, an equity price shock will also affect investment via output itself.

Labour markets. It is assumed that employers have the power to manage, and hence the bargain in the labour market is over the real wage. In the long run, wages rise in line with productivity, all else equal. Given the determinants of the trajectory for real wages, if unemployment rises then real wages fall relative to trend, and conversely. The equations were estimated in an Equilibrium Correction format with dynamics estimated around the long run. Both the determinants of equilibrium and the dynamics of adjustment can change over time and adjustment, especially in Europe, is slow. We assume that labour markets embody rational expectations over the inflation rate and we assume that wage bargainers use model consistent expectations, either for the immediate period ahead or over a longer-term horizon. These compensation equations are discussed at some length in Barrell and Dury (2003) and all these equations are dynamically homogenous.

2.2 Policy rules

Fiscal and monetary policy rules are important in 'closing the model' and the rules are discussed at greater length in Barrell and Dury (2000). We use simple rules that are designed to reflect policy frameworks rather than optimal rules.

Fiscal Policy rules Budget deficits are kept within bounds in the longer term, and taxes rise to do this. This simple feedback rule is important in ensuring the long run stability of the model. Without a solvency rule (or a no Ponzi games assumption) there is no necessary solution to a forward-looking model. The simple fiscal rule can be described as

$$Tax_t = Tax_{t-1} + \phi\, [GBRT - GBR] \qquad (11)$$

Where Tax is the direct tax rate, GBR and GBRT are the government surplus target and actual surplus, ϕ is the feedback parameter, which is designed to remove an excess deficit in less that five years.

Monetary Policy Rules It is assumed that the monetary authorities adopt simple targeting rules that stabilise the price level or the inflation rate in the long term. If we use different rules in different countries then some of the difference we observe would depend on that policy choice and in this paper we use the same rule for all countries[7]. The European Central Bank (ECB) has been set the objective of maintaining price stability in the medium term. It has set itself a target for inflation within the constraints of a nominal target for the stock of money,

[7] We chose not to implement the 'industry standard' Taylor rule in part because the standard has not yet been agreed for multi country models and shocks that change the world equilibrium real interest rate.

and it describes this as the two-pillar strategy[8]. A combined policy of nominal aggregate and inflation rate targeting would give:

$$r_t = \gamma_1 (P_t Y_t - P*_t \, Y_t*) + \gamma_2 (\Delta P_{t+j} - \Delta P_{t+j}*) \qquad (12)$$

The combined rule is chosen as the default monetary policy rule because it represents the mixed framework that is used in Europe by the European Central Bank (ECB). We choose to use it elsewhere as the proportional controller on inflation dominates responses. Note that a fiscal expansion in the model leads to inflation via changes in the saving/investment balance – given the monetary policy rule, this will drive up short rates and hence long rates, given equation (3).

2.3 Model residuals for equity prices, consumption and income

In assessing the behaviour of the global economy during the bear market using the model, it is important to evaluate the cross-country correlation of unexplained components of key variables, which indicate structural shocks. There are many sources of structural shocks and we can address their changing nature by looking at a selected set of structural equation shocks from NiGEM, and we choose consumption, compensation (the main component of personal income) equity price and business investment residuals to see if there are noticeable correlations across countries. Specifications of these equations are as described in Section 2.1[9].

Table 2 looks at the correlation of these structural shocks across countries between 1991q1 and 1999q4. We present correlations with the US, which is our main interest in the present context of the transmission from the US to the rest of the G-7. It is evident that the correlations between countries for consumption, business investment and for the compensation variable residuals are low. On the other hand the correlation of the unexplained

[8] European Central Bank (2001). We do not target money, as this is a poor indicator of the underlying target, which we take to be nominal GDP.

[9] See also Barrell, Becker, Byrne, Gottschalk Hurst and van Welsum (2003) for a discussion of these equations and of model properties.

component of the equity price equation is high over this period except for Japan. It is especially high for France, the UK and Canada vis a vis the US equity market. This suggests that transmission of shocks affecting consumption and to a lesser extent investment tends to occur indirectly via asset prices and does not impact on expenditures or incomes directly.

3 The 2000-2 bear market

The interest in equity price simulations is of course heightened by share price trends in recent years. Equity markets fell around 50% over 2000-2, and it is clear that we have witnessed a bear market comparable to that of the early 1970s, as is discussed in Davis (2003). Table 3 derived from Davis (2003) shows that unconditional volatility exhibited a steady rise over 1972-5 with conditional volatility (measured using GARCH(1,1) estimation) starting higher and rising less. Unconditional and conditional volatility saw a peak in 1998 after which unconditional volatility declined sharply before rising again, while conditional volatility was also on a gradual uptrend albeit never recovering the level of 1998. The differences between the two types of volatility are potentially instructive, given conditional volatility is a closer proxy for expectations. In 1972, unconditional volatility was below conditional, suggesting uncertainty in markets at the sustainability of the bull market. Thereafter conditional volatility fell somewhat short of unconditional, especially for the US in 1974 and the UK in 1975 when markets were hit by unpredictable and uncorrelated shocks such as the oil shock as well as expected volatility. Similarly, in 1998 the markets may not have anticipated the level of volatility seen in the Russia/LTCM crisis and hence unconditional was highest, but thereafter as the bear market took hold it was conditional volatility that tended to be higher till 2002 when unconditional was again higher.

The correlation of domestic share prices with world indices tends to increase in bear markets, reducing the seeming diversification benefits of international investment. Typically, this pattern is thought to reflect common behaviour of institutional investors as well as common fundamentals across the world. Global financial integration has ensured a much higher level of average correlations than in 1975 at the trough of the earlier bear market (Table 4); the highest correlation is apparent late in the bear market in 2001 and 2002, with all countries except Japan having correlations of 0.88 or more with the world index. In this period, the increased covariance of equity markets may also reflect common factors in the re-evaluation of profits.

Trends in risk premia are one of the key elements in the background to the bear market. There are generally substantially higher returns to saving in equities than other forms of asset holdings, but risk aversion and the need for liquid assets for precautionary and transactions purposes ensures that these holdings never dominate entirely. Theoretical portfolio models often predict a level of risk aversion, which is much lower than that necessary to explain the level of share holdings (for recent evidence see Haliassos and Michaelides, 2000). In particular, the equity premium puzzle suggests that over the past century or so, stocks were not sufficiently riskier than bonds to explain the spread in their returns (Mehra and Prescott, 1985).

Evidence from the 1990s suggested that the risk premium had declined or disappeared, possibly due to the institutionalisation of portfolios (Blanchard 1993), although there may also have been a cyclical element in the recent equity bull market, whereby risk premia fell everywhere for reasons that may not have been fully justified. Madsen and Davis (2003), for example, suggest that the response of share prices to productivity shocks was inappropriate, since the impact of the latter on profitability is temporary. The bear market may in this context be viewed partly as a correction of unsustainably low risk premia.

As shown by Jagannathan et al (2000) the risk premium can be proxied by the dividend yield plus expected dividend growth less the real bond yield. IMF (2001) argue that the growth in potential output can be used to proxy expected earnings and dividend growth. Accordingly, Table 5 below shows a measure of the risk premium using a Hodrick Prescott filter on GDP growth to proxy dividend growth[10]. The stylised fact that premia declined in the 1980s and virtually disappeared in the 1990s is confirmed. The sizeable estimated risk premium in the low-inflation 1960s shows that the decline was not merely a consequence of the impact of disinflation on real bond yields. The peaks of the bull markets in 1972 and 1999 show vast differences in estimated risk premia, albeit in each case generally below the decade-average, underpinning the suggesting of a bubble in 1999, while 1972-5 is better explicable in terms of fundamentals.

4 Analysing the Impact of Equity Prices

Using the NiGEM model we undertook a number of simulations to assess the impact of an equity price decline and the appropriate policy responses (the baseline is a forecast over 2003-6). Our major concern was to assess the impact of a US stock market decline on the US and on other economies, with a particular focus on international propagation. This can take place through trade, through the impact of US equity prices on wealth in other countries, through fixed investment and through contagion to other countries' equity markets.

We first undertook a simulation using the NiGEM model of a re-evaluation of future profits in the US equity markets, engineering a fall of 34 percent in the equity price in the US. We induce a temporary increase in the perceived equity risk premium, with it slowly declining back to historical levels after 14 years[11]. This large equity price shock in the US spreads to the rest of the world through trade and asset holdings, and is denoted *US Premium* in the tables in section 4.1. This simulation involves only a re-evaluation of the US equity price, and does not affect the risk premium in the investment decision, and hence it works only through wealth effects. We return to this issue in section 4.2.

We look at the impact of the collapse of equity prices on demand in the US and its impact on trade. Some of the potential impact of the fall on the US is absorbed by diversified portfolios,

[10] We use the National Institute forecast of output in each of the G7 in the filter to avoid end point problems.
[11] See Barrell (2002) for a discussion of the assumptions.

and spreads to wealth elsewhere[12]. Contagion to other countries takes place through equity markets as well as through trade and the impact on the value of foreign holdings of US assets. We can define such contagion in several ways. We note that the experience of the last three years, discussed above, is outside the range of correlations observed in the 1990s (Table 2), and hence using historical correlations of structural residuals to calibrate the expected change in the equity premium elsewhere is not an adequate description of recent events. Accordingly, we simulated a fall in the risk premium of the same magnitude everywhere, except in Japan, and this is noted as *All Premia* in the tables in section 4.1. The Japanese premium fall is 40% of that in the US, which is consistent with the correlations in the previous section. Equity price falls are lower in other countries than in the US, reflecting in part the greater impact of equity prices on the US economy and hence greater second round effects on equity prices. In particular the greater the impact of the shock on output, the proportionately greater the impact is on future profits, and hence their discounted future value changes more. Similar declines in equity premia generate falls of equity prices of 30% in the UK, 26.5% in Canada and 18.5% in the Euro Area on average as compared to 33% in the US.

Smaller falls in equity prices in Europe than in the US are not consistent with recent events which show equity price falls comparable to or greater than the US for all countries, at least to the end of 2002. Thus, we did a further simulation with a fall of 35% in share prices everywhere except in Japan, where the fall was 40% of that elsewhere. This simulation is designed to reflect the pattern of correlation in equity prices that we have seen in the most recent bear market, and which suggest that in the last four years the equity risk premium has risen more in Europe than it has in the US. This simulation denoted *All Equity Prices* in the tables in section 4.1.

It is possible that the re-evaluation of the US equity risk premium could also affect the investment decision, although we are of the opinion that some at least of the overvaluation of

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[12] We undertook a simulation where wealth contagion was 'cut off and its effects are noted below.

the stock market was purely a financial bubble based on market perceptions of profitability that were not shared by firms undertaking investment[13]. Accordingly, in section 4.2 we extended our US Premium shock and shifted the investment risk premium in the US by half of the amount of the change in the equity premium in order to replicate over our simulation period the 2000-2 decline in the level of investment in the US. Finally, in section 4.3 we extended our All Premia shock by allowing contagion from equity markets to the investment decision in all countries. We calibrated the investment risk premium in the US and elsewhere to ensure that the fall in investment in the US emulated that seen in 2000-2002, as in the previous simulation.

4.1 Equity Shocks

The results of our three equity simulations are reported in Table 6. It is clear that in all cases the fall in output is largest in the US, reflecting larger wealth effects. In the case of the rise in the *US premium* alone, the results for other countries are driven by lower US demand as well as effects on wealth of US shares in foreign portfolios. It is partly offset by lower bond yields, as discussed below. The simulation gives a 2% fall in US GDP, with much smaller effects elsewhere[14]. The decline in US equity prices reduces long term interest rates everywhere, albeit by more in the US, (see changes in table 7. This raises bond prices everywhere, offsetting the direct impact of US equities on wealth elsewhere. In Japan, GDP is particularly boosted owing to the effects on bond prices, while Japanese investors hold few equities.

Contagion to other equity markets increases the scale of the shock in the US, especially when *all equity prices* fall. In this case there is a 20 per cent greater decline in output in the first two years of the scenario. This reflects both the trade effects of lower output elsewhere and the impact of lower wealth in the US because of a decline in the value of foreign assets. The

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[13] Equivalently we might say that the managers of companies such as ENRON were aware of the implications of their accounting practices, and did not allow the inflated equity price to affect their investment decisions.
[14] If we restrict contagion via wealth effects (implicitly assuming all US assets are held domestically), the impact on US output is greater, with US output being 0.25 and 0.5 percentage points further below baseline in the first

impact of the equity market collapse is doubled in Canada if equity prices fall everywhere by the same amount as in the US. Euro Area output drops between a 1/3 and 2/3 of a percentage point more below baseline if equity prices fall by similar amounts everywhere. Effects of *all premia* are intermediate.

There are marked disinflationary effects of the shocks, especially in the US, because demand is lower, and hence inflation and output fall below baseline. Disinflationary effects are greater when there is contagion of share price falls. In response, the monetary authority is expected to cut nominal rates now and in the future. Reflecting these patterns, Table 7 shows that US nominal and real long rates also fall in each simulation, along with the effective exchange rate. All these changes help absorb the shock in the US, although the fall in the US effective exchange rate propagates the shock. Table 8 gives the changes in exchange rates under the set of shocks. In general, currencies other than the US dollar appreciate, and propagation takes place through competitiveness effects in addition to the demand and wealth effects. However, the appreciation is less when the equity price shock propagates to other countries, and this helps absorb some the extra shock suffered outside of the US.

It is useful to trace the monetary reaction in the model and in the world in more detail. We have undertaken simulation with equity-based wealth permanently lower as a ratio of GDP and hence in the simulation saving has to rise to achieve the wealth-income ratio embedded in the Euler equation for consumption. This changes the saving and investment balance and ceteris paribus, investment will be less than saving. If this happens, nominal rates would be cut in every period that inflation and output would be below target. Nominal rates will be cut until demand reaches capacity and inflation settles on target, and this requires that the real interest rate is lower period by period than it is on our baseline. Hence the long real rate is also lower. Long real rates fall elsewhere, but not by as much. Euro Area rates fall by 75% of

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and second years of the analysis. Wealth in Canada would be 3.25% higher, in the UK it would be 2% higher, whilst in the Euro Area it would be 1% higher than in the US premium shock.

the US fall, for instance. Canadian and Euro Area inflation rates fall by between 0.4 percentage points and 0.5 percentage points over the first four years of the simulation, increasing with the impact on income, but moderated by the smaller appreciations associated with equity price contagion.

4.2 Contagion to Investment in the US

If the increase in the equity market risk premium changes perceptions of future profits within firms or the cost of finance to firms, the effects of a fall in equity prices will be larger. A rise in the risk premium on investment (a fall in Tobin's q) would reduce investment, and we have calibrated the US risk premium to induce a fall in investment to match that seen between 2000 and 2002. As we can see from Table 9, which shows the additional change over *US Premium,* output would be 1 per cent further below baseline in the first year after the shock in the US if there were contagion to investment, and in the third year it would be around 4 per cent lower than if we had just witnessed deflation of an equity bubble that had not figured in firms' investment decisions[15]. The impact on US GDP is sustained for longer, and output is below baseline for two more years if there is contagion to investment. US long rates fall more if there is contagion to investment. In our baseline they are 4% in the first year, and would fall to 2.5% in the US Premium scenario and to under 1% in the contagion to investment scenario. Long real rates also fall but by less than nominal rates, as inflation also falls over the medium term.

The increase in impact on other countries is greatest for Canada which has the closest trade ties with the US. The effect on the UK is also marked because of trade ties. The contagion effects to other countries are partly offset by larger falls in long rates which raise bond prices boosting consumption, and lower long real rates which raise investment. Net financial wealth in the Euro Area and particularly in Japan is more heavily weighted to government bonds, and

[15] However, in neither case do we generate a sustained recession. Output growth is negative for 2 quarter in the first year in our US Premium scenario and negative for 3 quarters in our contagion to investment scenario.

bond prices rise as a result of the fall in real rates. These effects are large enough to fully offset the impact of lower US output on Japan, and offset it within two years in the Euro Area.

4.3 Contagion to global investment

If the equity premium shock was propagated to the Euro Area and the rest of the world as we suggest above, there may be an increase in the risk premium on European and other countries' fixed investment, albeit on a smaller scale than in the US. We have repeated the worldwide equity premium shock (which is smaller in Japan than elsewhere) and we have added propagation to investment to it everywhere. For comparability we have calibrated the shock to produce the same fall in US investment in the first two years as in section 4.2, and the rise in the risk premium on investment in other countries is 50% of that in the US.

In Table 10 we compare the results of our experiment with a US only premium shock where there is contagion to investment in capital. The fall in investment in the US is by choice the same in the first two years, but the fall in output is larger when the risk premium on investment rises elsewhere, in part because the US real exchange rate falls by 5 per cent rather than 10 per cent, and hence less of the shock in the US is absorbed in competitiveness. This fall in the exchange rate reflects the forward looking nature of the model, with future anticipated loosening of monetary policy in Europe and elsewhere being reflected in the exchange rate now.

The UK, Canada and the Euro Area initially have a higher output than when the shock is just in the US, in part because of the competitiveness differences. In addition, lower nominal long-term interest rates raise bond prices everywhere, and this raise wealth especially in the Euro Area. However, after the first year of the simulation the effects on output are greater outside the US when we have propagation to investment as well as equity prices, and the effects are more sustained than in any of the other shocks we analyse. After 4 years, output in the Euro Area would only just have returned to around baseline in this simulation.

The fall in nominal and real long-term interest rates that this large shock generates is a worldwide phenomenon, but in order to emulate the correlations in section 2 we have shocked Japan significantly less than other countries. Hence the negative impact of the shock is more than offset by the impact of the fall in long rates on wealth and investment.

4.4 Policy Responses to the Shock

The impact of the shock is not given solely by the behavioural relationships of the private sector, asset price dynamics and the pattern of trade and asset holdings, but also depends on the policy response of the authorities. As noted, NiGEM has inbuilt rules which target inflation in the case of monetary policy and seek budget balance over 5 years in the case of fiscal policy. The monetary policy rules use the short-term interest rate as an instrument, and long-term interest rates are determined by the market in the light of their expectations of future short-term rates given their knowledge of the feedback rule and the structure of the economy. For example, long-term interest rates in the US tend to fall by over 1 percentage point as equity prices fall because the markets are aware that the authorities will reduce rates in response to lower demand and inflation. Interest rates also fall elsewhere in response to the propagation of the shock, with the size of the cut being dependent on the size of the shock.

It is useful to analyse the impact of easier monetary policy via raising the response to inflation of the monetary authorities in the monetary rules. However in our baseline beginning in 2003, such a scenario of a larger US monetary response - cutting interest rates beyond the rule to stimulate demand - runs into a liquidity trap, as shown in Chart 1. It can only work through further falls in long rates resulting from delayed increases in short rates. Hence we concentrate on the monetary response in the rest of the world. We assume in the extra monetary response scenario that the coefficient on inflation in the feedback rule used by all central banks outside the US is doubled[16]. Given the disinflationary impact of the equity price shock, interest rates are cut further. Table 11 shows that the impact on GDP of the US equity

[16] We used r =0.75(inflation – target)+ .5(Nominal output –target) and then we raised 0.75 to 1.5

price shock can be attenuated by a monetary response, notably in the Euro area. Prices, and hence inflation rates, are higher in the case of further monetary easing in Canada and the Euro area, and in the UK in the medium term.

Although the US does not have the possibility of significant changes in monetary policy in our baseline, except from working down the yield curve, it still has the possibility of loosening its fiscal stance. Our standard mode of operation has a fiscal feedback rule in place from the start of the run, and this will induce a rise in direct taxes in response to the reductions in revenues and increases in spending that come from the reduction in demand and output that follow from the equity shock. There are various ways to change the fiscal response in the US, but the simplest is to assume that the fiscal feedback rule does not operate for the first five years of the scenario (denoted "turning solvency off").

As shown in Chart 2, this will induce an increase in the budget deficit, and after 6 years the US debt stock would be more than 2 percent of GDP higher than it would otherwise have been. As can be seen from Chart 2 the real long term interest rate is 0.10 to 0.18 higher than it would otherwise have been in response to an increase in the US deficit of 0.45 per cent of GDP on average over 5 years. It would be possible to simulate a direct fiscal response to the decline in equity prices, and indeed we may have seen that in the US, where the budget has moved from a surplus of around 1.5 per cent of GDP in 2000 to a deficit of 31/4 per cent of GDP in 2002. A change of this scale, even after cyclical adjustment for the 2 per cent difference in the output gap, would induce a rise in long-term real rates of over 1 percentage point.

The impact of the fiscal loosening on GDP is given in Table 12. Clearly, the US is the main beneficiary, and output would be 1.5 per cent below where it would otherwise have been in 2004, instead of being 2 per cent below as in the US premium shock (the difference in the table is 0.44 in that year). Output attenuation from a US fiscal response is greatest in Canada because of the scale of the trade links and the direct impact on demand. However, some of the potential expansionary effects will be offset by higher real interest rates in the US and elsewhere, and this is sufficient to offset the demand effects in the UK and the Euro Area, and to a lesser extent in Japan.

4.4 Summary of the scope of contagion

We have looked at a sequence of shocks and concerned ourselves with propagation mechanisms. We used NiGEM to show that a US equity market shock is propagated in a number of ways. Generally, the more equity price contagion, the lower output globally. On the other hand, if we cut off wealth effects then US output falls considerably more in that country. This in part reflects the speed at which wealth feeds into consumption in the US as compared to other countries, and we may describe the overall effect of interlinking wealth as spreading risks and reducing the impact of shocks, much as theory would suggest. If the equity risk premium shock spreads to the risk premium on US investment then the impact on output in the US would be much larger, but some of the impact elsewhere would be absorbed by lower long term nominal interest rates (raising wealth through bond prices) and lower long term real interest rates (raising investment as compared to where it would otherwise have been).

We may summarise the scale and routes of contagion by looking at charts that plot the fall on output over the first 3 years of our *US Premium* scenario, which involves a rise in the US equity premium with no contagion to US investment or to other equity prices. There is clearly little relationship across countries between the size of the fall in output and the wealth to income ratio, as we can see from Chart 3.

However, we can decompose the wealth effect, and look at the relationship of output to direct equity holdings in Chart 4. The pattern is relatively clear, and there is a correlation of -0.67 between the two. The same pattern holds in Chart 5 with total direct and indirect equity holdings where the correlation is -0.68. Clearly the composition of wealth matters more than its size and our model attempts to allow for this by distinguishing between revaluations of equities and bonds.

We can also correlate the structural factors we have discussed with the change in the (NIESR forecast and filter based) output gap estimator for 2000-2 for the G7 economies[17]. During this period the US output gap is estimated to have opened by 2.0 percentage points, Canada by 1.5, the Euro Area (as a whole) by 1.4, Japan by 1.1, and the UK by 0.75. Of course there were many shocks that drove these changes, but equity markets were an important factor, and propagation from the US equity market was central to the cycle. There is little correlation between the rise in the output gap and wealth to income amongst the G7 economies, but the correlation with directly held equities is -0.47, whilst with all equities it is -0.27.

Our model also reflects the pattern of trade, and we plot two indicators in Charts 6 and 7 below. The correlation between the output effect outside the US and exports as a percent of GDP is strong at -0.87 as can be seen from Chart 6. However, trade with the US also matters, and the correlation there (including Canada, which we do not plot because around 1/3rd of GDP is exported to the US) is -0.77.

Of course direct trade patterns are not the only channel of trade related contagion, and the model will take account of second and third round impacts on trade. We also allow for major impacts to come through changes in competitiveness, which in the short run help absorb the shock in the US and propagate it to the rest of the world. These patterns are not dissimilar to those seen between 2000 and 2002, where the correlation outside the US between the opening of the output gap and our openness indicators is -0.31 for all trade and -0.42 for US trade as a per cent of GDP.

[17] See Barrell and Mitchell (2003) for a discussion of these Approximate Band Pass filter estimates of the output gap which uses data from the 1960s through to the end of our forecast base in the 2020s.

5 Conclusions

Equity prices falls over 2000-2 have been comparable to the bear market of the mid 1970s, although evidence of a bubble is much stronger in recent years (given the low level of the risk premium) and correlations between equity markets have been much stronger. Based on estimated relationships, falls in equity prices of the scale observed can have significant recessionary effects on the world economy. Composition of wealth, openness and trade patterns are among the key factors, which influence the scope of output responses internationally. Monetary easing can help absorb such a shock, although monetary policy reactions can be constrained by the liquidity trap as in the US and Japan in the simulation. Fiscal policy loosening can also help offset the effects of a collapse in equity prices, but it will mean higher long term real interest rates and hence it moderates one of the automatic shock absorbers provided by the market mechanism. In the US we have probably seen a fiscal loosening on a scale that is almost sufficient to offset the impact on real interest rates of the fall in equity prices between 2000 and 2002.

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Table 1: Household wealth-income ratios

	UK	US	Germany	Japan	Canada	France	Italy
Net financial wealth/personal disposable income ratio							
1998	3.87	3.96	1.54	2.96	2.45	2.45	2.83
1999	3.34	4.42	1.65	3.27	2.46	2.92	3.03
2000	3.35	4.09	1.62	3.30	2.43	2.83	2.98
2001	2.82	3.41	1.59	3.32	2.36	2.56	2.63
Net illiquid financial wealth/personal disposable income ratio							
1998	2.95	2.75	0.46	1.22	1.81	1.59	2.12
1999	2.60	3.22	0.58	1.42	1.85	2.02	2.39
2000	2.56	2.70	0.60	1.38	1.88	2.00	2.27
2001	2.02	2.19	0.57	1.31	1.86	1.74	1.91
Memo: Personal sector direct equity holdings/personal disposable income ratio							
2001	0.59	0.85	0.36	0.34	0.99	1.08	0.62
Memo: Total direct plus indirect equity holdings/total financial wealth %							
2000	53.4	48.5	27.1	13.1	39.8	47.8	30.5

Source: National flow-of-funds balance sheet data, Datastream

Table 2: Correlation of structural shocks between US and others

	Consumption	**Compensation**	**Business Investment**	**Equity Prices**
France	0.121	0.454	0.224	0.513
Germany	0.048	-0.189	0.006	0.334
Italy	-0.038	-0.158	-0.132	0.352
UK	-0.499	0.241	0.118	0.646
Japan	-0.072	-0.307	-0.234	-0.098
Canada	0.118	0.112	0.281	0.551

Table 3: Average volatility of share prices in the G-7 (per cent)

	Standard deviation	Conditional volatility	Difference		Standard deviation	Conditional volatility	Difference
1972	3.68	5.23	-1.55	1998	7.23	6.16	1.08
1973	5.57	5.47	0.10	1999	4.81	5.65	-0.85
1974	6.85	6.50	0.34	2000	5.08	5.79	-0.71
1975	7.13	6.98	0.16	2001	5.97	5.82	0.15
				2002	6.85	6.22	0.63

Source: MSCI

Table 4: Correlation of share prices with world indices

	UK	US	Germany	Japan	Canada	France	Italy	Country averages
1998	0.92	0.94	0.87	0.75	0.93	0.81	0.72	0.85
1999	0.71	0.97	0.88	0.61	0.85	0.86	0.54	0.77
2000	0.78	0.96	0.44	0.54	0.81	0.66	0.22	0.63
2001	0.96	0.98	0.95	0.72	0.89	0.95	0.90	0.91
2002	0.98	0.99	0.95	0.40	0.88	0.97	0.95	0.88
Memo item:								
1975	0.72	0.96	0.51	0.72	0.72	0.50	0.69	0.69

Source: MSCI

Table 5: Estimated risk premia

	Germany	US	UK	France	Canada
1960-69	7.6	4.4	4.5	6.6	5.1
1970-79	5.8	7.5	9.4	11.4	7.6
1980-89	2.3	1.8	3.2	4.1	1.1
1990-94	0.8	1.7	1.9	-0.3	-1.2
1995-99	0.4	0.4	1.6	-0.1	-0.6
Memo: 1972	5.9	3.5	4.3	8.9	5.3
Memo: 1999	0.0	-0.4	1.0	-0.4	-0.1

Table 6: GDP Effects of Equity Premia and Equity Price Shocks

(percentage point difference from baseline level)

		Year 1	*Year 2*	*Year 3*	*Year 4*
Canada	*US Premium*	-0.70	-1.16	-1.00	-0.66
	All Premia	-1.15	-1.89	-1.66	-1.17
	All Equity Prices	-1.52	-2.54	-2.10	-1.18
Euro Area	*US Premium*	-0.56	-0.28	0.17	0.48
	All Premia	-0.69	-0.41	0.15	0.57
	All Equity Prices	-0.91	-0.90	-0.30	0.30
Japan	*US Premium*	0.38	0.50	0.18	-0.08
	All Premia	0.47	0.62	0.24	-0.08
	All Equity Prices	0.42	0.13	-0.50	-0.69
UK	*US Premium*	-0.62	-0.50	-0.32	-0.21
	All Premia	-0.74	-0.82	-0.61	-0.36
	All Equity Prices	-0.83	-1.08	-0.78	-0.29
US	*US Premium*	-1.95	-2.03	-1.07	-0.37
	All Premia	-2.03	-2.09	-1.00	-0.21
	All Equity Prices	-2.39	-2.51	-0.90	0.40

Table 7: US Effective Exchange Rate and Long Rates

percentage points difference from baseline in first year

	Long rate	Real long rate	US Effective Exchange Rate
US Premium	-1.40	-1.25	-4.81
All Premia	-1.50	-1.35	-4.35
All Equity Prices	-1.02	-1.12	-2.63

Table 8 Impacts on Exchange Rates versus US dollar in Year 1

Percent difference from baseline

	Canada	**Euro Area**	**Japan**	**UK**
US Premium	-2.39	-6.10	-9.13	-8.65
All Premia	-1.12	-5.85	-9.47	-7.13
All Equity Prices	0.14	-3.74	-6.43	-4.88

Table 9 Output impacts of contagion to investment in the US

Percent difference from US Premium

	Canada	**Euro Area**	**Japan**	**UK**	**US**
Year 1	0.33	-0.05	0.91	-0.44	-1.09
Year 2	-0.25	0.29	1.54	-0.48	-3.30
Year 3	-1.08	0.46	1.13	-0.58	-3.93
Year 4	-1.56	0.58	0.34	-0.59	-3.36

Table 10 Output impacts of contagion to global investment and all premia

Percent difference from US Premium with Contagion to US investment

	Canada	**Euro Area**	**Japan**	**UK**	**US**
Year 1	0.35	0.88	0.73	0.51	-0.60
year 2	0.12	-0.18	0.96	-0.94	-0.73
year 3	-0.10	-1.01	0.90	-2.00	-0.22
year 4	-0.08	-1.19	0.43	-2.46	0.64

Table 11: Impacts on Output of a Larger Monetary Reaction outside the US

(Percentage difference in GDP from US Equity Premium results)

	Year 1	*Year 2*	*Year 3*	*Year 4*
Canada	0.16	0.23	0.20	0.15
Euro Area	0.37	0.60	0.40	0.15
Japan	0.03	0.02	0.00	0.02
UK	0.14	0.21	0.04	-0.07
US	-0.02	0.03	0.05	0.02

Table 12: Impact on Output of Turning Solvency off in the US

(Percentage difference in GDP from US Equity Premium results)

	Year 1	*Year 2*	*Year 3*	*Year 4*
Canada	0.04	0.19	0.29	0.26
Euro Area	0.07	0.08	0.03	-0.04
Japan	0.13	0.07	-0.12	-0.19
UK	0.08	0.05	-0.02	-0.05
US	0.15	0.44	0.46	0.23

Chart 1: US Short Rates in Premium and Equity Shocks

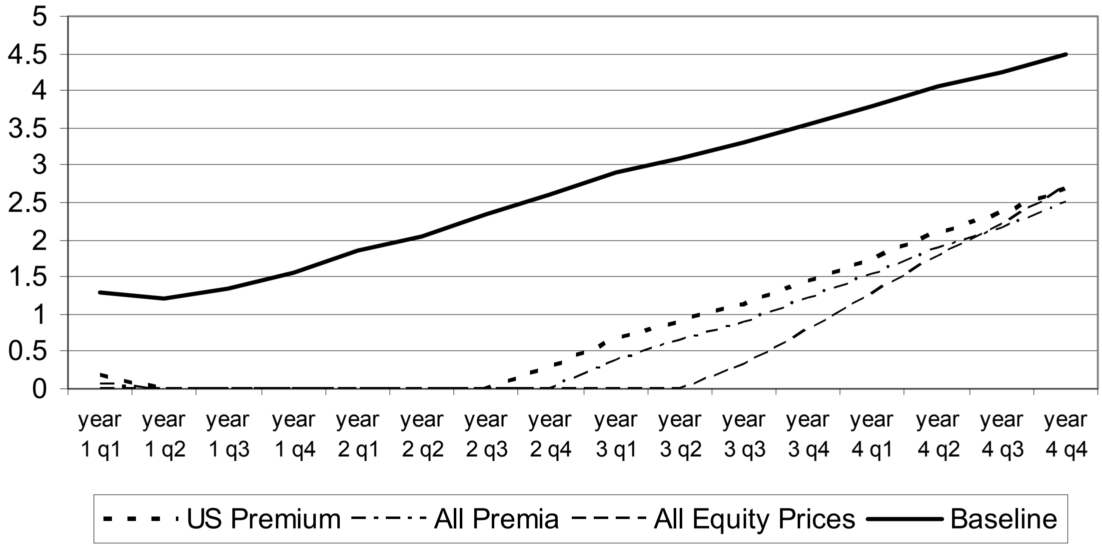

Chart 2: Turning off Solvency:
The Impact of Fiscal Policy on Real Interest Rates

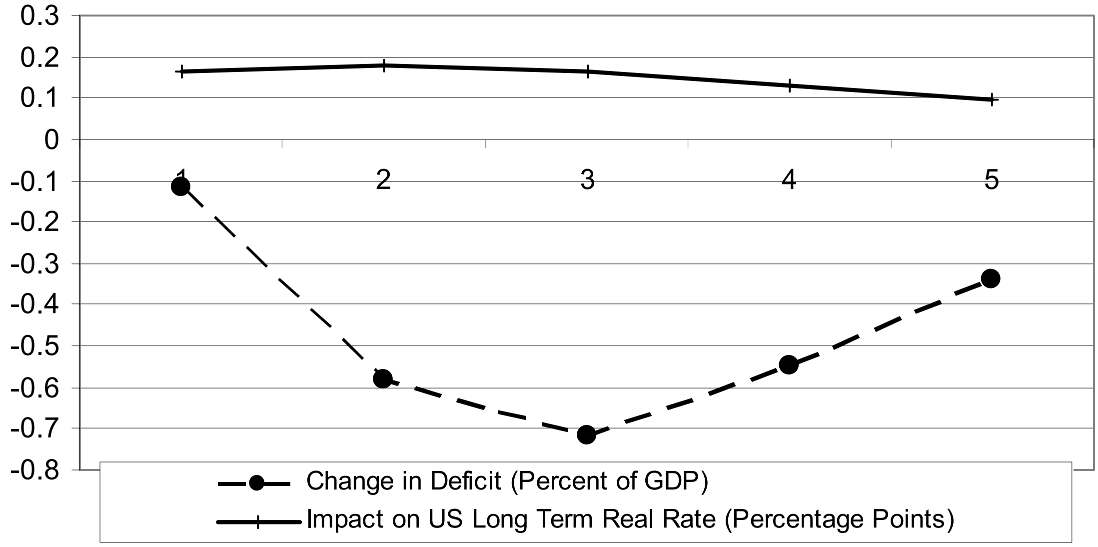

Chart 3 Output and Wealth Effects

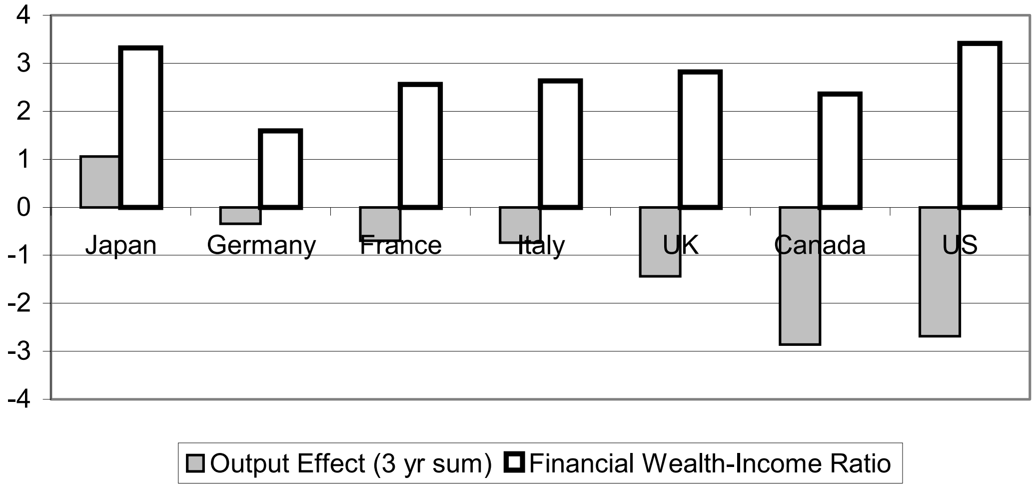

Chart 4 Output Effect and Equity Holding

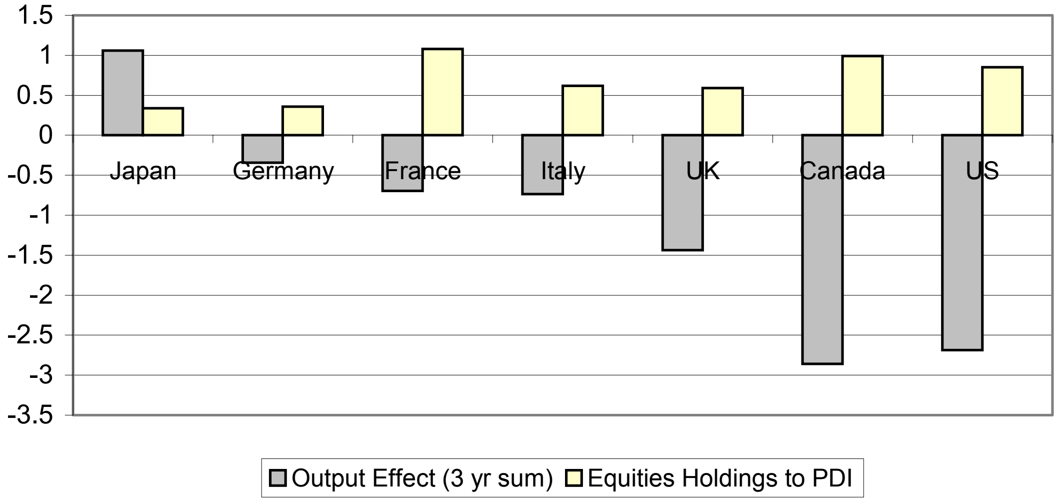

Chart 5 Output Effect and Total Equity Holdings

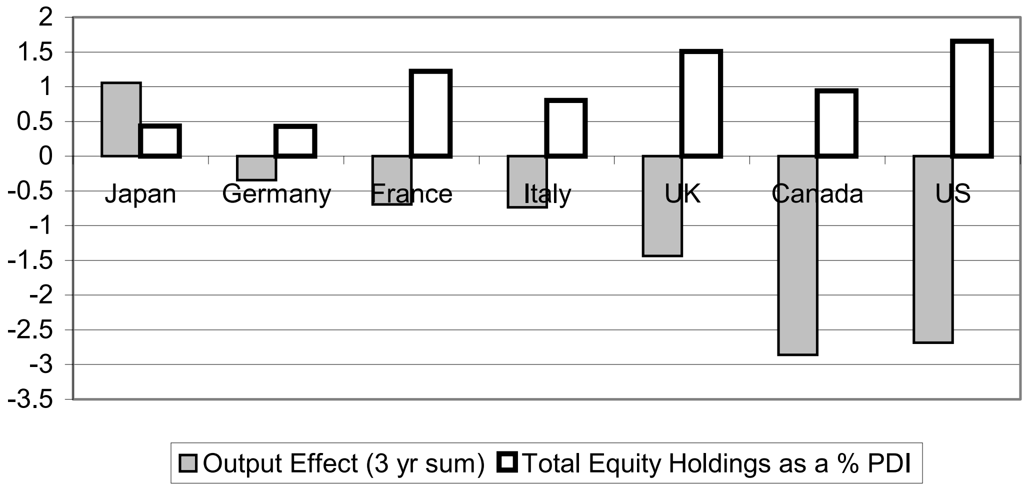

Chart 6 Output Effect and Openness
Correlation = -.85 excluding the US

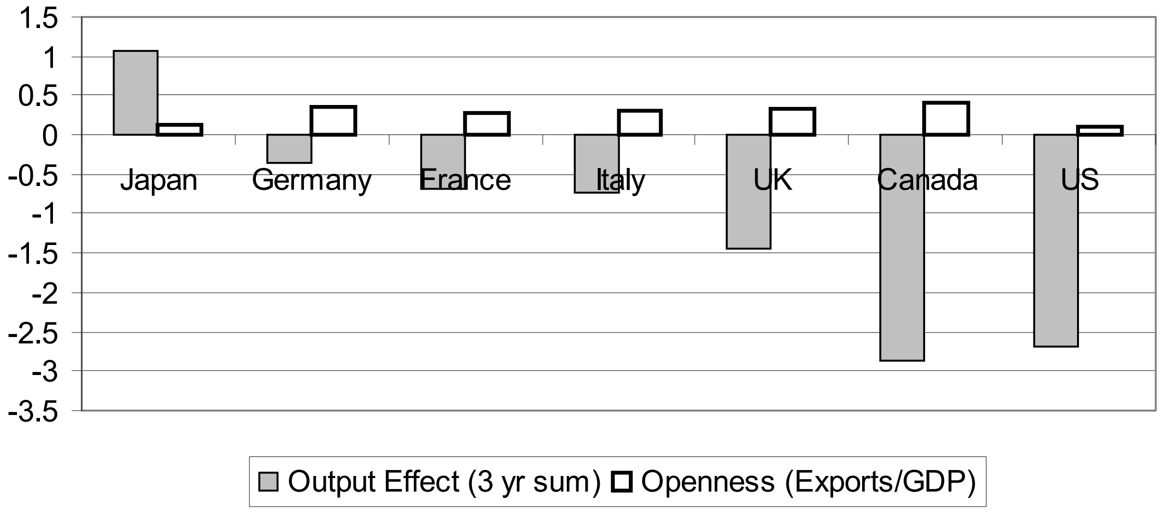

Chart 7 Output Effect and Exports to the US