THE AGGREGATE ECONOMIC COSTS OF US STOCK MISPRICING [1] [2]

Prof R. Bird*
Dr G. Menzies*
Prof P. Dixon**
Dr M. Rimmer**

* Paul Woolley Centre for Capital Market Dysfunctionality
University of Technology, Sydney
** Centre for Policy Studies, Monash University

Draft Only: Do not Quote

Abstract

Stock mispricing can lead to misallocation and wastage of capital both inter-temporally and across sectors. The USAGE model for the United States is used to quantify economic costs under a number of mispricing scenarios, made operational by shocking Tobin's q. A two-year Communications and Technology investment boom increases consumption by a Net Present Value (NPV) amount of nearly one per cent, partly due to a positive investment externality onto the US terms of trade. If the investment is wasted, however, this gain in consumption is more than offset, leading to a loss of nearly one-half of a per cent. A protracted 'capital strike' across the whole economy subsequent to the boom – mimicking financial distress from a burst bubble – shaves around 7 per cent off consumption if the strike lasts for 3 years, and 10 per cent if it lasts for 5 years.

---

[1] Address for correspondence. ron.bird@uts.edu.au +61 (0)2 95147716.

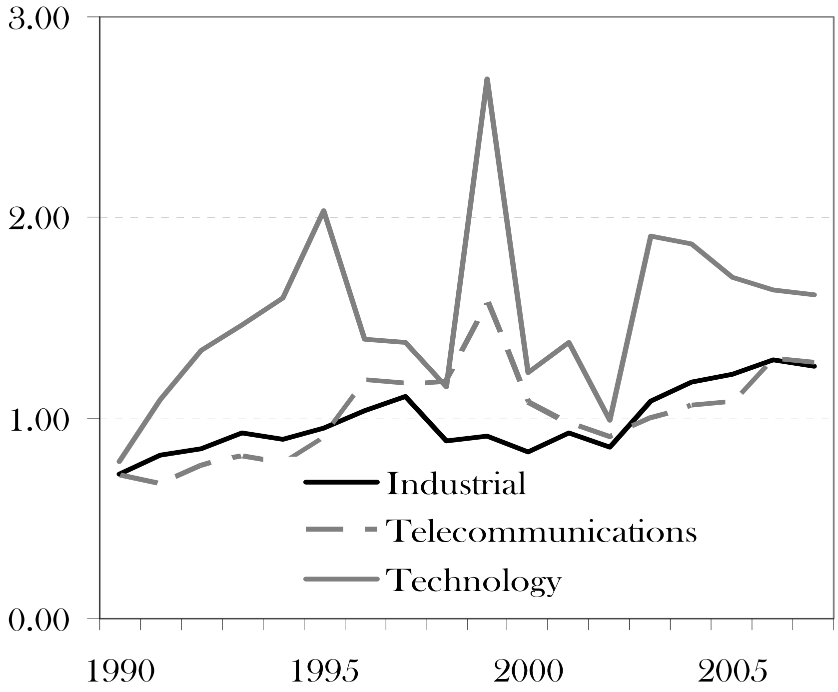
[2] We wish to acknowledge the generous support of the Paul Woolley Centre at UTS, without which this work would not have been possible. We thank Danny Yeung for Research Assistance.

Introduction

"If the reason that the price is high today is only because investors believe that the selling price will be high tomorrow – when 'fundamental' factors do not seem to justify such a price – then a bubble exists." (Stiglitz 1990, p.13)

Asset Price Bubbles have burst onto the pages of history for well over 400 years. The Dutch tulip blub bubble of 1636, the South Sea bubble of 1720 and the internet bubble of the late 1990s (Figure 1) furnish a few spectacular examples (Kindleberger, 2000).

Figure 1: Tobin's q: Industrials, Telecommunications and Technology



Source: Datastream

Bubbles are characterised by high levels of momentum trading and herding amongst investors. Accordingly, asset prices will continue to rise as long as the investors (i.e. speculators) believe that they can sell the asset for a higher price in the future.[3]

---

[3] Other definitions are given by the New Palgrave: *"….a sharp rise in the price of an asset or a range of assets in a continuous process, with the initial rise generating expectations of further rises and attracting new buyers—generally speculators interested in profits from trading in the asset rather than its use or earnings capacity"* (Eatwell et al., 1987, p. 281), by Shiller (2003) *"a period when investors are attracted to an investment irrationally because rising prices encourage them to expect, at some level of consciousness at least, more price increases. A feedback develops—as people become more and more attracted, there are more and more price increases. The bubble comes to an end*

It is widely believed that the rapid boom and bust associated with asset price bubbles have real effects on the economy, with the 1929 crash and subsequent Great Depression writ large in many memories. The negative impact of bubbles being attributed the misallocation of capital due to the market mispricings and the subsequent distress within the financial sector. Yet no consensus about the magnitude or inevitability of these effects has emerged (Posen, 2006).[4]

The focus of this paper focus is on measuring the aggregate of economic costs associated with bubbles and their after-math. We obtain our estimates by utilising a computable general equilibrium (CGE) model to simulate the impact in a single economy of false expectations in the equity market (i.e. market mispricings). The model that we use is the USAGE model which is best described as a contemporary policy model of the United States economy (US International Trade Commission, 2004 & 2007). We shock this model with market mispricings and then trace the mechanism by which this translates through the economy to eventually measure the impact that this has on future GDP growth and consumption relative to the case where there is no market mispricings.

We begin, in section 2, by reviewing the debate about the impact of mispricing. The literature focuses on two distinct mechanisms which can affect the real economy – financial sector distress and misallocation.[5,6] This sets the stage for designing three stock mispricing scenarios which are applied to the US economy. Section 3 explains the model

when people no longer expect the price to increase, and so the demand falls and the market crashes.", and, by Siegel (2003) who proposes that a bubble is any two-standard-deviation departure from the expected return. Using his methodology, however, he fails to find a bubble in the US over the past 120 years! Monte Carlo studies also suggest low predictive power using his method (Simon 2003).

4 In his words:"*it is difficult even to establish that bubbles bursting is all that harmful, at least in developed economies, even though that harm is often taken for granted"* (op cit. 2006, p.6).

5 With regards to financial stress following a bubble, the literature on these effects presumes the ability to econometrically test for bubbles, yet this is no trivial matter. Gürkaynak (2008) provides a comprehensive survey on the tests including variance bound tests (as in Shiller, 1981), West's two-step test (1987), integration/co-integration tests (Dibba and Grossman 1987, 1988) and intrinsic bubble tests (Froot and Obstfield 1991). After canvassing the strength and weakness of each type of tests, Gürkaynak summed up the state of the state of econometric testing:*"…..*[This] *survey of econometric tests of asset price bubbles shows that, despite recent advances, econometric detection of asset price bubbles cannot be achieved with a satisfactory degree of certainty. For each paper that finds evidence of bubbles, there is another one that fits the data equally well without allowing for a bubble. We are still unable to distinguish bubbles from time-varying or regime-switching fundamentals, while many small sample econometrics problems of bubble tests remain unresolved." (Gürkaynak 2008, p.166)*

6 There is no attempt in this paper to decompose the aggregate economic costs into those attributable to financial distress and that attributable to misallocation. Subsequent work is aimed at making this distinction with preliminary results suggesting that the bulk of the costs is due to financial distress.

qualitatively, drawing on the canonical Mundell-Fleming and optimal capital stock diagrams. Section 4 gives the quantitative results and Section 5 concludes.

2 Asset Mispricing in the Literature

Asset price bubbles are commonly associated with an increase of debt. During the boom phase of the bubble, the large distortion in relative prices induces investors to increase their debt burden. Shiller (2003) provides an example of this mania when he relates the story of university students 'maxing out their credit cards' to buy shares during the height of the internet bubble, and Posen (2006) describes American households utilising cash-out refinancing on the equity in their house during the housing booms. Once the bubble bursts, many investors default on what prove to be unsustainable loans.

However, when investors default *en mass*, some believe that the instability of the banking/financial system, rather than the stock market crashes *per se*, is the major macro-economic concern. Mishkin and White (2002) marshal history for the defence of this distinction. They show that there was severe economic damage only for 8 of 15 US stock market crashes in the last 100 years. And, only some of these 8 episodes resulted in recessions. They conclude that in the absence of financial instability, stock market crashes had negligible effects on the economy. In this, they concur with Posen (op. cit.) who cautions against central banks bursting bubbles.[7]

While perhaps dispelling the notion of *inevitable* economic distress, historical analysis may provide only limited insight into a rapidly evolving financial system. Indeed, as a result of increasing competition and financial deregulation, financial institutions have aggressively sought income from non-core lines of business, such as asset trading (International Monetary Fund, 2000).[8] As a consequence of this, they have significantly increased their exposure to the real economy as the sub-prime crisis is making abundantly clear.

---

[7] He writes: 'In the end, there is no monetary substitute for financial stability, and no market substitute for monetary ease during severe credit crunch' (op. cit. page 1)

[8] To quote them: "*Greater exposure to asset market developments implies that sharp swings in stock and property prices, such as those observed over the last two decades, tend to have a major impact on the balance sheets of financial institutions. One direct channel is through revaluations of non-loan assets and changes in earnings accruing from brokerage fees on the value of asset transactions…*" (op. cit., p.102).

Mispricing of assets may also affect the real economy by disrupting the optimal allocation of resources: "[They] *create wedges which could distort both inter-temporal investment decisions and cross-sectional capital allocations*" (Chrinko and Schaller 2007, p.84).

However, the issues are subtle, as Barlevy (2007) skillfully shows. He outlines a number of situations where bubbles have redeeming features. First, he draws a surprising link between the literature on the theoretical justification for money, and bubbles. The fundamental consumption value of money varies moment by moment without a change in price, so its unchanging value can be interpreted as an ongoing speculative bubble![9] This theoretical curiosity serves as a reminder that imperfections in the economy – here the socio-economic frictions that necessitate money – can sometimes be fixed by other distortions, a point related to the Theory of the Second Best (Lipsey and Lancaster, 1956).[10]

The literature descending from Diamond (1981) gives the same story. The *whole* underlying economic environment that led to the emergence of the bubble will have large bearing on its likely costs and benefits. In Diamond's model, agents may either buy an intrinsically worthless asset, or invest. Under certain technical conditions, the price of the intrinsically worthless asset is positive, implying a bubble.[11] In the particulars of his environment, a bubble is socially beneficial, because it draws resources away from already over-accumulated capital.[12] Naturally, as Oliver (2000) points out, bubbles in

---

9 No central bank wishes to prick this inexhaustible source of seigniorage.

10 To quote them (op. cit. pg. 11) 'It is well known that the attainment of a Paretian optimum requires the simultaneous fulfillment of all the optimum conditions. The general theorem for the second best optimum states that if there is introduced into a general equilibrium system a constraint which prevents the attainment of one of the Paretian conditions, the other Paretian conditions, although still attainable, are, in general, no longer desirable. In other words, given that one of the Paretian optimum conditions cannot be fulfilled, then an optimum situation can be achieved only be departing from all the other Paretian conditions. The optimum situation finally attained may be termed a second best optimum because it is achieved subject to a constraint which, by definition, prevents the attainment of a Paretian optimum.'

11 The condition is that the economy grows faster than the rate of interest, which implies over-accumulation of capital.

12 The result is reversed in Saint-Paul (1992) and Grossman and Yanagawa (1993). In their extensions of Diamond's model, there is an under-accumulation of capital and so the drawing away of resources exacerbates the problem.

assets that are complements to capital accumulation may be optimal if capital is under-accumulated.

Bubble externalities are plausible in a number of real-world contexts. Barlevy (op. cit.) shows how a housing bubble can lead to better allocation of houses. In the US, the tax liability on one's house is based on historic cost. This discourages trading, because in an environment of real dwelling appreciation, staying put forestalls the unfavorable re-valuation of the tax liability. A housing price bubble, with its associated increase in trading, encourages the social benefits of relocation, even though it has other costs.[13]

It is not hard to imagine other situations of investment externalities. The difficulties of capturing profits from innovation lead to under-investment of R&D in the economy. A speculative bubble, if it encourages R&D investment, may lead to advantages which at least mitigate the obvious disadvantages of such a bubble. In this paper, it turns out that there is an investment externality on the terms of trade, via the exchange rate. A stock market boom leads to investment which, in turn, appreciates the real exchange rate. The appreciating US dollar, ceteris paribus, improves the terms of trade.

There is very little prior empirical evidence on the aggregate economic costs of assets bubbles and their aftermath. However, a recent IMF paper by Laeven and Valencia (2008) examines numerous recent financial crises and measures their cost in terms of GDP by comparing the subsequent actual GDP growth with extrapolated GDP growth based on the trend prior to the crises. In total, they considered 124 banking crises and found that they were on average associated with a reduction in GDP of 13%. However, it should be noted that the vast majority of the crises examined occurred in developing economies.

3 The USAGE Model and its Application

3.1 The Usage Model

[13] He gives the example of a neighbourhood which is perfect for young families, where the residents stay longer than is socially optimal (after their children grow up) because of the tax disadvantages of re-locating.

USAGE is a dynamic Computable-General-Equilibrium model of the US economy, with a similar structure to the MONASH model for the Australian economy (Dixon and Rimmer, 2002). Usage can be run with up to 500 industries, 700 occupations 23 trading partners and 51 regions (50 states plus D.C.).[14]

USAGE includes three types of dynamic mechanisms: capital accumulation; liability accumulation; and lagged adjustment processes.

Capital accumulation is specified separately for each industry. An industry's capital stock at the start of year t+1 is its capital at the start of year t plus its investment during year t minus depreciation. Investment during year t is determined as a positive function of the expected rate of return on the industry's capital.[15]

Liability accumulation is specified for the public sector and for the foreign accounts. Public sector liability at the start of year t+1 is public sector liability at the start of year t plus the public sector deficit incurred during year t. Net foreign liabilities at the start of year t+1 are specified as net foreign liabilities at the start of year t plus the current account deficit in year t plus the effects of revaluations of assets and liabilities caused by changes in price levels and the exchange rate.

Lagged adjustment processes are specified for the response of wage rates to gaps between the demand for and the supply of labor by occupation. There are also lagged adjustment processes in USAGE for the response of foreign demand for U.S. exports to changes in their foreign-currency prices.

In a USAGE simulation of the effects of shocks, we need two runs of the model: a basecase or business-as-usual run and a shocked run. The basecase is intended to be a plausible forecast while the shocked run generates deviations away from the basecase caused by the shock under consideration. The basecase incorporates trends in industry

---

[14] It was developed starting in 2001 as a joint project between the Centre for Policy Studies, Monash, and the US International Trade Commissiion. To date, its main uses have been for trade, energy, environment and immigration policy.

[15] The investment specification for the MONASH model, adopted in USAGE, is discussed in appendix 1.

technologies, household preferences and trade and demographic variables. These trends are estimated largely on the basis of results from historical runs in which USAGE is forced to track a piece of history. Most macro variables are exogenous in the basecase so that their paths can be set in accordance with forecasts made by expert macro forecasting groups such as the Congressional Budget Office. This requires endogenisation of various macro propensities, e.g. the average propensity to consume. These propensities must be allowed to adjust in the basecase run to accommodate the exogenous paths for the macro variables.

The shocked run in a USAGE study is normally conducted with a different closure (choice of exogenous variables) from that used in the basecase. In the shocked run, macro variables must be endogenous: we want to know how they are affected by the shock. Correspondingly, macro propensities are exogenised and given the values they had in the basecase. More generally, all exogenous variables in the shocked run have the values they had in the basecase, either endogenously or exogenously. Comparison of results from the shocked and basecase runs then gives the effects of moving the shocked variable(s) away from their basecase values.

Some particularly pertinent features of the model for our purposes are discussed in more details below:

Production technologies and household preferences

USAGE contains variables describing: primary-factor and intermediate-input-saving technical change in current production; input-saving technical change in capital creation; input-saving technical change in the provision of margin services; and input-saving changes in household preferences. We assume that our investment shock has no effect on technology or household preferences.

Inflation, monetary policy and fiscal policy.

The model lacks an explicit monetary and fiscal authority. Implicitly, the Mundell-Fleming assumption of perfect capital mobility means that infinitesimal interest rate changes move the nominal exchange rate. Equilibrium is attained via expenditure-switching adjustments in the real exchange rate.[16] Thus, the simulations share a shortcoming of all macro models that rely on expenditure switching as a channel; the margin of simulation error must be large, mirroring the longstanding and well-documented volatility of nominal exchange rates (Frankel and Rose 1995).

Investment and rates of return.

For this paper, we assume that expected rates of return are generated by projecting current information. This is convenient because it allows the model to be solved recursively (in a sequence, one year at a time). We do not consider that the alternative, rational expectations, would add realism.

USAGE contains functions specifying the supply of funds for investment in each industry as an upward-sloping function of the industry's expected rate of return. Our shock consists of shocking the functions so that (in the case of optimism) a given expected rate of return results in higher investment, and (in the case of pessimism) the same given rate of return results in lower investment compared with the basecase. The investment function is explained in detail in appendix 1.

3.2 The Scenarios

We now focus on three particular bubble scenarios. We simulate these scenarios by shocking Tobin's *q* in the USAGE model of the United States.

Our measure of *q* is dominated by movements in the market value of ordinary shares,[17] so, a shock to *q* in USAGE is the same as a share market boom. In the model, this leads to extra investment as the value of capital rises relative to its required return. The model has a function that relates real expected returns to investment (see Appendix 1). Since expected returns in the model can be related to Tobin's *q* (see Appendix 2) we have the necessary positive connection between share prices and investment.

---

[16] The simulations are therefore not tailored to provide insights into policy responses (optimal or otherwise). With all the macroeconomic adjustment coming through net exports, the required movements in the exchange rate are probably larger than in reality.

[17] We use (Market Value of Ordinary shares + Book Value of Preference Capital + Total Debt)/Total Assets, 1980-2007. The numbers are based on over 100,000 US firms in the Datastream database.

The basic shock in this paper is an increase in *q* for two years in a boom sector (Telecommunications and Technology combined). Notionally, the shock happens over the years 2006 & 2007, but the deviation-from-control results are transferable to any baseline forecast at any point in time.[18] This shock is common to all scenarios which differ in terms of the aftermath to the shock and these are set out in more details below:

(i) *Scenario 1* where there is an initial two year bubble where investors hold overly optimistic expectations as to the returns that will be generated by investing in the Telecommunication and Technology industries which is then immediately followed by a return to normality where the investors have realistic expectations.

(ii) *Scenario 2* has the same two years of optimistic expectations followed by a return to normality as in *Scenario 1* but in this case the additional investment that flows from these unrealistic expectations are completely wasted. In other words, the investments are completely wasted in that they have a present value of zero and do not add to the capital stock. This is an instance of a misallocation of capital attributable to the pricing that flows from false expectations in equity markets.

(iii) *Scenario 3* which is identical to *Scenario 2* except that the aftermath of the bubble is not only capital wastage but also an extended period of pessimism where investors under-estimate the returns that will be generated across all firms. In other words there is a capital strike which may reflect extreme caution by investors who have just had their finders burnt and/or a lack of access to capital attributable to a meltdown in financial markets. Under this Scenario, we investigate capital strikes that extend over three years, five years and perpetuity.

3.3 A Simple Insight

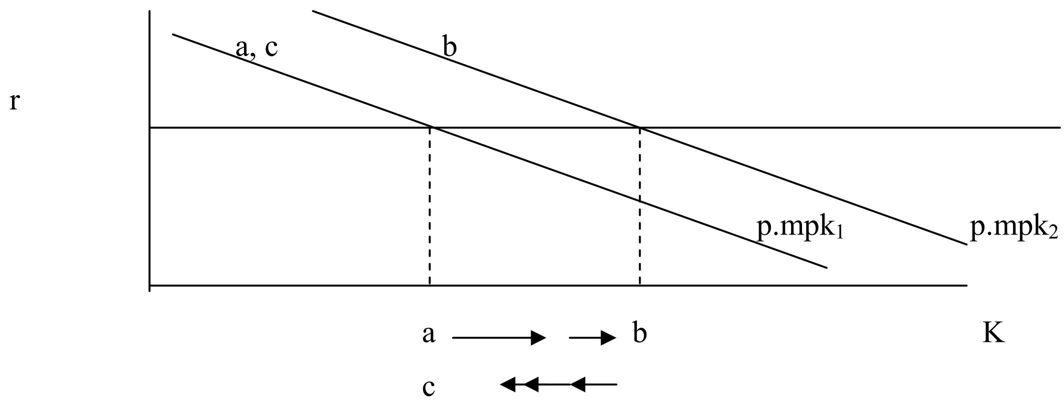
In this sub-section we provide a simple introduction to the workings of the model in order to provide some intuition for the findings that we present in the next section. The basic shock that we introduce into the model to replicate an asset bubble can be illustrated with

---

[18] This follows from the approximate linearity of USAGE.

the standard diagram for the choice of capital in the neoclassical economy, where rental=p_{output}.(marginal productivity of capital).

Figure 2 Desired Capital Stock for a Reversed Shock



Consider the economy described by *p.mpk*$_1$. Since we want to allow people to be wrong sometimes, we will think of this as the *expected* value-of-capital schedule. The desired capital stock is shown on the K axis at point *a*, where the last installed unit of capital creates exactly enough output, worth *p.mpk*$_1$, to pay its rental rate *r*. In a stylised way, one may think of (*p.mpk)/r* as a type of Tobin's *q*, since it is the value of capital divided by its cost. If capital is at its desired level, this measure of *q* is clearly unity.

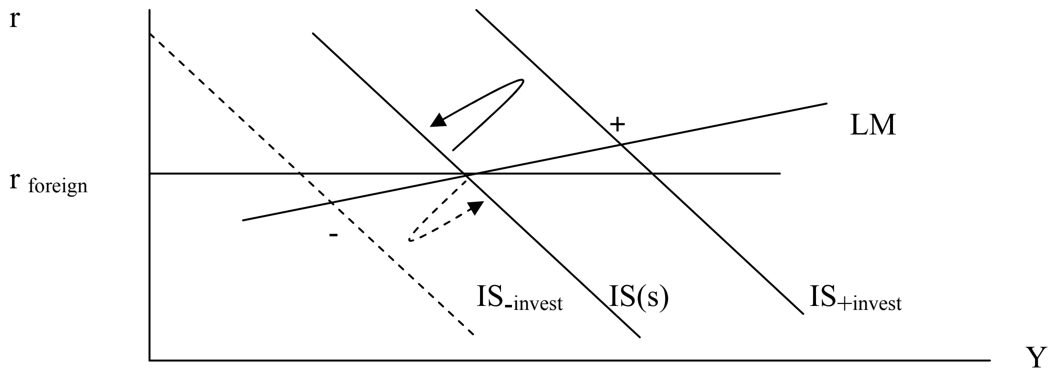
Now, consider a shift up in the expected value-of-capital schedule – from *p.mpk*$_1$ to *p.mpk*$_2$. This corresponds to a boom in the value of a sector's stock prices driven by optimism about future profits. We assume capital doesn't adjust in the first instant, so *q* rises above unity. It is, in fact, the ratio of the vertical distance between point *a* on the K axis and the new value-of-capital schedule *p.mpk*$_2$, to *r*.

Over the two years of the higher expected value-of-capital stock, this optimism translates into investment expenditure, shown by the arrows on the K axis. To simplify the diagrammatic exposition, assume that it reaches the new desired level of *b* in the two years.

The shock is withdrawn in the third year, and the expected value-of-capital schedule returns to its original position *p.mpk*$_1$. The capital stock now has to be dis-invested, since it is 'stuck' at too high a value of *b*. Capital is extra-marginal at this value, and *q* is less than unity. In the instant following the reversal, *q* is the ratio of the vertical distance between point *b* on the K axis and the restored value-of-capital schedule $p.mpk_1$, to *r*. We assume dis-investment happens through a process of capital-stock depreciation.[19] This occurs over a number of periods and eventually capital returns to its desired level.[20]

How does investment and disinvestment transmit to the macro-economy? The USAGE model does not have a feedback rule whereby monetary policy stabilises the economy via interest rates. Instead, the real exchange rate stabilises the model through net exports, via the standard Mundell-Fleming mechanism.

Figure 3 Investment and Net Exports



For every occasion in Figure 2 when autonomous investment[21] increases or decreases, the IS curve in Figure 3moves out or in. The real exchange rate *s* shifts IS via net exports.[22]

If autonomous investment increases ($IS_{+invest}$) the equilibrium interest rate and income point '+' is unsustainable. The real exchange rate rapidly appreciates since interest rates are higher than foreign rates, hurting export competitiveness, and driving the IS curve back to its starting equilibrium. Similarly, If autonomous investment decreases (dashed

---

[19] The diagram in Appendix one shows that the capital stock cannot fall by more than the depreciation rate.

[20] By making a levels statement we implicitly ignore steady-state growth in the diagram, though this is not the case in the USAGE model.

[21] In terms of the ISLM model, this is an increase in investment for a given interest rate, which is precisely what is seen in Figure 2 when the value-of-capital schedule moves.

[22] An increase in s is an appreciation. In the simplest model with autonomous consumption and unit marginal impact of interest rates on investment, $y = c+i+g+netx = c+[i_{aut}-r]+g+netx$ leading to an IS curve of $r = (c+i_{aut}+g+netx) - y$. The intercept of this IS curve will move in proportion to changes in autonomous investment i_{aut} or changes in netx, the latter being determined by the real exchange rate.

$IS_{-invest}$), the point '-' is unsustainable and the real exchange rate depreciates restoring the initial IS.[23]

Algebraically Y=C+I(autonomous I)+G+NX(s) can return to the initial equilibrium with unchanged Y, C and G ($\Delta Y=\Delta C=\Delta G=0$) only if $\Delta I + \Delta NX = 0$. This can be brought about by an increase/decrease in investment being exactly offset by a decrease/increase in net exports, which in turn implies an appreciation/depreciation in s.[24] With regard to the vanishingly small increase in interest rates, we may say that international capital has an infinite supply elasticity, so no increase in world returns is necessary to fund the increase in the exchange rate.

With the aid of these two diagrams, we may describe the effects of three bubble scenarios.

In the **scenario 1**, a bubble in the share market leads to productive investment being brought forward in time, as the expected value-of-capital schedule shifts out. There is a boom in investment for two years (Figure 2).[25] The positive investment each year leads to real exchange rate appreciation and a fall in net exports. When the shock is reversed, investment falls for two years, the exchange rate weakens and net exports recover (Figure 3).

In the **scenario 2**, a bubble in the share market leads to *unproductive* investment, so there is no sense in which investment is being brought forward. To be precise, the expected value-of-capital schedule shifts out, as before, but the supposed additions to the capital stock are in fact useless. Capital remains at point *a* in Figure 2. The boom in investment for two years still occurs and the real exchange rate appreciates, since *the productivity or*

---

23 In USAGE, interest rates do not change, so we have to imagine an infinitely flat LM curve, which will deliver the exchange rate change for an infinitesimally small change in the domestic interest rate. More formally, in logs suppose $m-p= y-b.(r-r^*)$. This can be re-written as $r=(1/b)(p+y-m)+r^*$. This is an LM curve, but it can also be interpreted as a quasi-Taylor rule. A flat LM curve means b is infinite, which means a very lax monetary authority. However, provided the interest rate is at the Wicksellian neutral rate, and there are no monetary shocks, inflationary/deflationary spirals are ruled out a priori.

24 This is an intuition, not a proof, which requires that we know that a final stable equilibrium exists, and that consumption and income are returned to their initial value. The Mundell-Fleming model provides a framework in which this is true.

25 Though capital adjusts does not fully adjust to its new desired level as it did in Figure 2.

otherwise of spending is irrelevant in the demand-driven IS/LM framework. Importantly, when the shock is reversed, *investment has no need to adjust down*, since it is realised that the (un-augmented) capital stock is actually the desired one at the end of the shock. Without the decline in investment the subsequent depreciation in the exchange rate does not occur because net exports do not need to rise (Figure 3).

Figure 4: Investment is more stable from year 3 *with* wastage

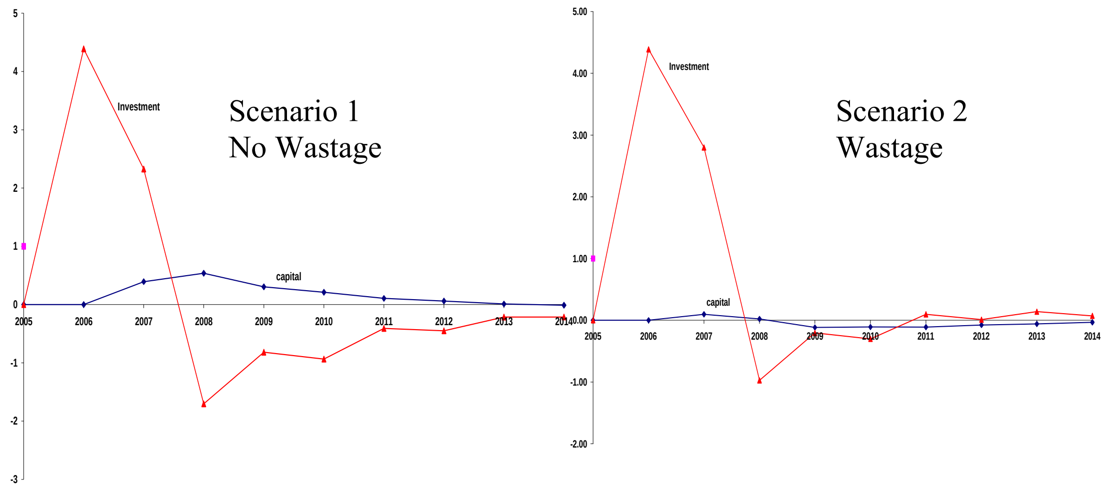


Figure 4 makes these mechanisms clear. The percent deviations from control for investment and capital are contrasted in the ‘no wastage’ and ‘wastage’ scenarios. The build up in capital in scenario 1 (see the line closest to the x axis) must be dis-invested following year 3, leading to a cycle in investment. No such cycle is evident in the right panel, however, because the investment boom in years one and two do not add to capital.

In **scenario 3**, we recognise the importance of ‘capital strikes’ whereby a spectacular unwinding of a bubble leads to a flight to cash, and a difficulty in obtaining funding for investment. We model this as a decline in the expected value-of-capital schedule in Figure 2, but in this case for the whole economy. Investment falls, the exchange rate depreciates, and net exports fill the vacuum in demand.

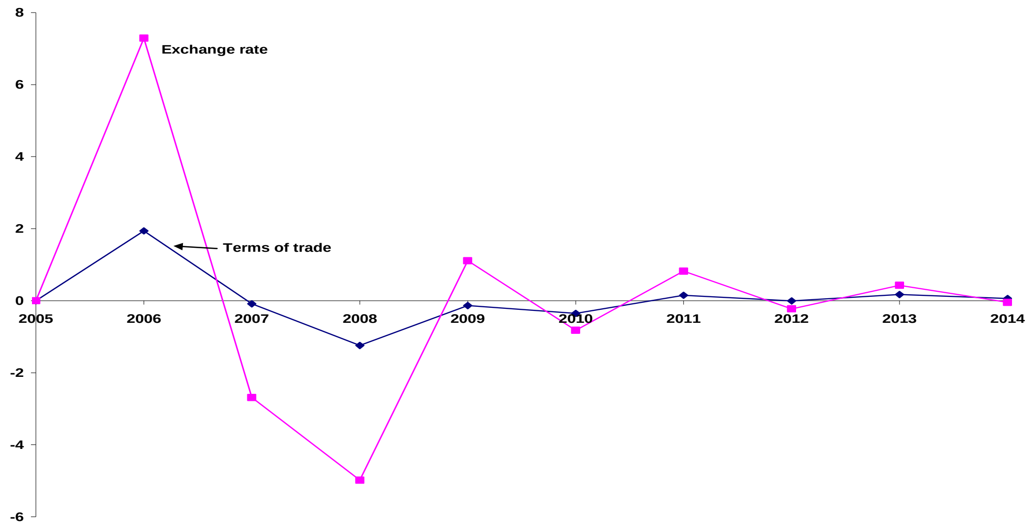
4 Quantitative Results

4.1 Overview

We begin by summarising the main results of the different scenarios, before providing detailed descriptions of the mechanism by which each shock works its way through the model.

In **scenario 1**, communications and technology *q* rises by one standard deviation for two years, before returning to baseline. Capital expenditure is brought forward, the exchange rate temporarily appreciates, and the net present value (NPV) of the consumption deviations is positive; equivalent to a one-off increase of 0.9 per cent, assuming a 5 per cent discount rate. This (small) positive benefit to consumption is consistent with Oliver (2000), and is driven by an exchange rate investment externality. In USAGE, an investment boom appreciates the $US which in turn improves the terms of trade. In Figure 5, the exchange rate deviates from control by nearly 8 per cent, lifting the terms of trade by 2 per cent compared with control. This externality is un-exploitable for decision makers in the model, who regard the currency as fixed for their choices.[26] There is also an additional effect on consumption from increased factor usage.[27] The size of the benefit is small, reflecting the envelope theorem.[28]

Figure 5: Appreciation improves the terms of trade



Scenario 2 has the same communications and telecommunications bubble as scenario 1, but the resultant capital expenditure is wasted. The consumption deviations are

---

[26] It should be noted as well that if the bursting of the bubble is associated with a general downturn in world demand, export prices may weaken further from year 3 onwards.

[27] Extra employment increases GDP and therefore consumption. At the margin, extra investment is funded by foreigners, but US residents capture the increased tax revenue (26% of the product).

[28] The envelope theorem implies that if capital is (close to) its inter-temporally optimal path, then small perturbations in timing of investment with have (close to) zero impact on consumption.

equivalent to a one-off loss of 0.4 per cent. Compared with scenario 1, the wasted investment costs consumers a one off amount of 1.3 per cent.

This is a highly intuitive result. Using the model database for 2006, the wasted capital in scenario 2 is worth about $150 billion. Only about 82 per cent of this belongs to U.S. residents. Thus the wastage of capital belonging to U.S. residents is worth about $123 billion. With private consumption in the U.S. being about $8739 billion in 2006, we would expect the capital wastage to ultimately impose a loss in consumption of about 1.4 per cent, closely in line with our result.

Scenario 3 is identical to scenario 2 except that a 'capital strike' (Tobin's *q* is one-half of one standard deviation lower) follows the boom of the first two year. The NPV of private consumption deviations are equivalent to a one-off loss of 31 per cent of consumption in year one. To understand this loss, we note that the pessimism infects the whole economy, rather than just two sectors, even though a one-half per cent decline in q can scarcely be described as an extreme assumption.

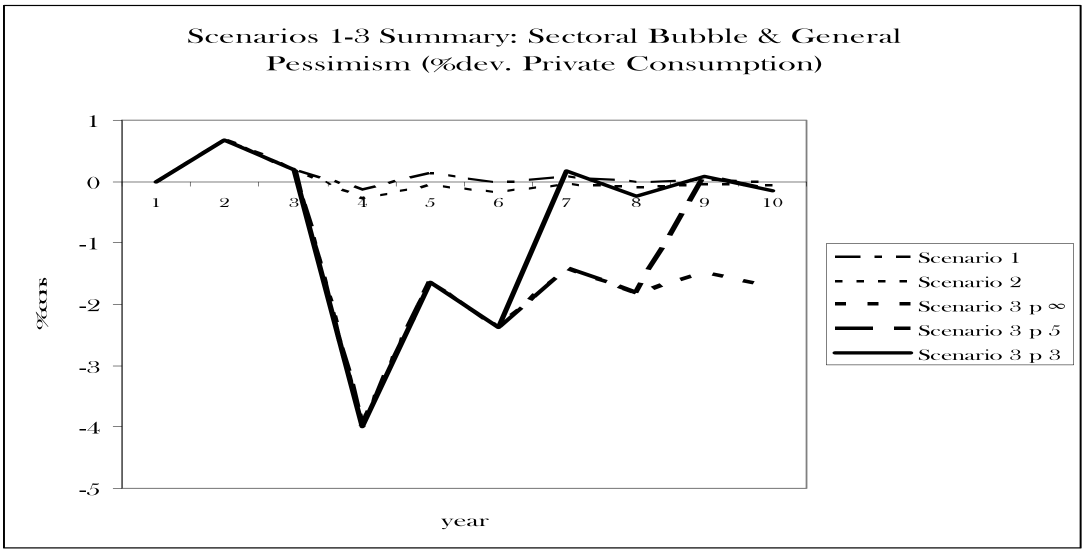
Nevertheless, we experimented with different capital strike durations. We allowed the market to return to normal after 3 years and 5 years. The one-off consumption loss, together with all the results of scenarios 1 to 3, is expressed as a share of Year 1 consumption, and Year 1 GDP.

Figure 6: NPV of Consumption Deviations, Scenarios 1-3

Scenarios		One-off %C NPV	One-off %GDP NPV
Scenario 1	(2-year exuberance: +1 % sectoral q)	0.9	0.6
Scenario 2	(Scenario 1 with investment wasted)	-0.4	-0.3
Scenario 3 p ∞	(Scenario 2 with -½ % economy q yr. 3 - ∞)	-31.0	-21.1
Scenario 3 p 5	(Scenario 2 with -½ % economy q yr. 3 - 8)	-8.9	-6.0
Scenario 3 p 3	(Scenario 2 with -½ % economy q yr. 3 - 6)	-6.5	-4.4

Figure 7 summarises the deviations from control (as a per cent of consumption) for the three scenarios, and the additional simulations for differing capital strike durations.

Figure 7: NPV of Consumption Deviations



4.2 Details[29]

The shock is operationalised through shifts in the investment function in equation (21.1) in Appendix 1. We shock $F\_EROR\_J_j$, when we want to simulate the effects of changes in expectations about industry j, and F_EROR, when we want to simulate the effects of changes in expectations generally.

Shocks to these two shift variables cause shifts along the curve shown in Figure 21.1. For a 'fundamental' rate of return (EQEROR in 21.1) a positive shock in either variable delivers more investment. This is equivalent to assuming that the expected rate of return has increased.

4.2.1 Size of shocks

We have information on Tobin's Q for 10 U.S. sectors for the years 1980 to 2007. As shown in Appendix 2, the expected rate of return, EROR(j), in industry j in USAGE can be related to Tobin's Q by the formula:

$$EROR(j) = \left[\frac{RINT + D(j)}{1 + RINT} \right] * (q(j) - 1) \qquad (1)$$

[29] Readers uninterested in technical details of the shock calibration might like to jump two pages to 4.2.2.

where RINT is the real rate of interest and D(j) is the depreciation rate in industry j. Assuming that real interest rates are 5 per cent and the rate of depreciation is about 7 per cent, (1) gives

$$EROR(j)=0.114*(q(j)-1) \quad (2)$$

The standard deviations for the annual q series for the Communications and Technology industries in the U.S. are 0.27 and 0.42.

In our simulations we assume that investors become exuberant in 2006 about Communications and Technology.[30] This moves q for these two industries up by one standard deviation. Thus the ERORs in (21.1) increase by 0.03078 and 0.04788 via the shock terms in (21.1).

We assume that exuberant expectations are maintained in year 2007. That means that we maintain the shift variables at their new positions.

In year 2008 the exuberant period ends. In simulations 1 and 2, the shift variables for Communications and Technology return to their initial positions. In simulations 3 the shift variables of the two industries return to their initial position but the general shift, F_EROR, moves up by 0.01026. Since this appears in (21.1) with a negative sign, this retards investment.

Why 0.01026? The average standard deviation in q across all industries is 0.18 (capital stock weighted average). In simulation 3 we assume that the unfulfilled expectations in Communications and Technology lead to widespread pessimism. We simulate this as a half of a standard deviation fall in q, so via equation (2) the appropriate shock across all industries is a downward shift of 0.01026 (= 0.114*0.09).

The difference between simulations 1 and 2 is that in simulation 2 the extra investment in Communications and Technology resulting from exuberance does not lead to extra capital in these two industries. The extra investment is wasted. The wastage assumption is continued in simulation 3.

---

30 This covers the Standard Industrial Classifications (SIC) of 48, 491, 4931, 357, 358 and 36.

4.2.2 Results

Simulation 1: Exuberance in Communications and Technology followed by return of expectations to normality

Chart 1.1 shows that combined investment in the two sectors moves about 40 per cent above control in 2006. It stays above control in 2007 by about 30 per cent. The smaller deviation in 2007 (about 30% compared with 40%) is caused by the extra capital that is available at the beginning of 2007. When expectations return to normal, investment sinks below the base. With normal expectations capital needs to return to its basecase level.

Chart 1.2 is the macro version of Chart 1.1. Technology and Communications accounts for about 9% of the economy's investment. Consequently, Chart 1.2 is close to a 9% scaled down version of Chart 1.1.

Chart 1.3 shows the paths of aggregate capital, employment and GDP. For each year, the deviation in GDP is approximately 0.7 times the deviation in employment plus 0.3 times the deviation in capital: 0.7 and 0.3 are the factor shares in GDP. Chart 1.5 shows the expenditure components of GDP. The initial boom in investment stimulates imports and retards exports. This happens via the exchange rate (Chart 1.6): an increase in investment generates real appreciation. Once the investment boom is over, exports move above control and imports move below control. In the long run, the effects on all macro variables are indistinguishable from zero.

The most interesting aspect of Chart 1.3 is the behaviour of employment. A helpful equation for explaining this behaviour is

$$\frac{W}{P_c} = \left(\frac{P_g}{P_c}\right) * MPL\left(\frac{K}{L}\right) \tag{3}$$

where

W is the average wage rate;

P_c is the price of consumption goods;

P_g is the price of GDP, that is the price of goods produced in the U.S.; and

MPL is the marginal product of labour which is a function of K/L, the capital/labour ratio.

If we cancel out P_c, (3) says that the wage is the value of the marginal product of labour.

As mentioned already, the positive deviation in aggregate investment in 2006 reduces exports. This improves the terms of trade (movement up the foreign demand curve). Against this, there is also an increase in imports which has a negative effect on the terms of trade (movement up the foreign supply curve). However, the net effect turns out to be positive (Chart 1.6). With an improvement in the terms of trade, P_g increases relative to P_c: the price deflator for GDP includes the price of exports but not imports whereas the price deflator for consumption includes the price of imports but not exports. In USAGE we assume sticky adjustment in real wage rates. That is, the left hand side of (3) moves slowly. Hence, with an increase in P_g/P_c we get an initial decrease in MPL. In the short run, K is fixed. Thus L must increase, giving the positive deviation in employment shown for 2006 in Chart 1.3.

With employment above control, wages gradually rise, forcing employment back towards control in 2007 (Chart 1.4). In 2008, when investment dips below control, the terms-of-trade gain for the earlier years is eliminated. However, wages have been elevated in these earlier years and take a while to adjust downwards. This produces a negative deviation in employment in 2008. In terms of equation (3), W/P_c is above control, P_g/P_c is back to control and so MPL must be above control. This produces a negative deviation in employment despite K being above control.

A surprising feature of Charts 1.3 and 1.4 is the failure of labour to return to control. Labour will eventually get back to control, but not until capital stops declining. Under our labour market specification, wages adjust down relative to control whenever employment is below control. This normally brings employment back to control. An exception is when there is some continuing bad news for employment. Then wages mightn't decline quickly enough to bring employment back to control. In the present simulation, the bad news is the downward adjustment in capital.

The behaviour of the exchange rate and the terms of trade in Chart 1.6 requires further elaboration. As mentioned already, the exchange rate appreciates in response to the increase in investment and devalues when investment contracts. Notice however that the exchange rate is already below control in 2007, even though aggregate investment is still about 2 per cent above control. Also, at first glance it seems curious that the real trade balance (exports minus imports) is still well below control in 2007 despite the exchange rate being below control.

How can the exchange rate go so low in 2007? It is easy to understand that the exchange rate must be weaker in 2007 than in 2006: investment is weaker in 2007 than in 2006. But how can it go below control? To understand how this can happen, let us assume to start with that the exchange rate in 2007 is back to the basecase. What would happen to exports? We think in terms of a diagram with foreign-currency prices on the vertical axis and export quantities on the horizontal axis. In USAGE, export volumes in year t are determined at the intersection of the short-run foreign demand curve and the U.S. supply curve. As explained in Appendix 3, appreciation in 2006 has the effect of moving the short-run foreign demand curve for 2007 to the left of its control position. If the exchange rate in 2007 is back at control, then the U.S. supply curve for 2007 will also be approximately back at control. Consequently, exports in 2007 would be below control. What would happen to imports? This time, we think in terms of a diagram with foreign-currency prices on the vertical axis and import quantities on the horizontal axis. Again as explained in Appendix 3, import volumes are determined in year t at the intersection of the foreigners short-run supply curve and the U.S. demand curve. Appreciation in 2006 has the effect of moving the short-run foreign supply curve for 2007 to the right of its control position. If the exchange rate in 2007 is back at control, then the U.S. demand curve for 2007 will also be approximately back at control. Consequently, imports in 2007 would be above control. Thus we can conclude that if the exchange rate in 2007 were at control, then the real balance of trade would be below control: lower exports and higher imports. Now we see the possibility (which actually occurs in our simulation) for the exchange rate to go below control in 2007 even though the trade balance is below control.

Chart 1.7 shows the deviations for private consumption (previously shown on a different scale in Chart 1.5). In is clear that the model does not pick up any penalty on consumption from having investment slightly mistimed. The present value of the consumption deviations is positive: a one off increase of 0.9 per cent. One explanation is that the U.S. makes an early gain from the extra investment via the terms of trade effect. Another factor is that the early investment means that the U.S. has extra capital income throughout the simulation period. While most of this belongs to foreigners, the U.S. benefits from extra tax collections associated with the extra capital income.

Chart 1.1. Exuberance in Communications & Technology followed by normality: Investment and capital in Communications and Technology industries (% deviation from basecase)

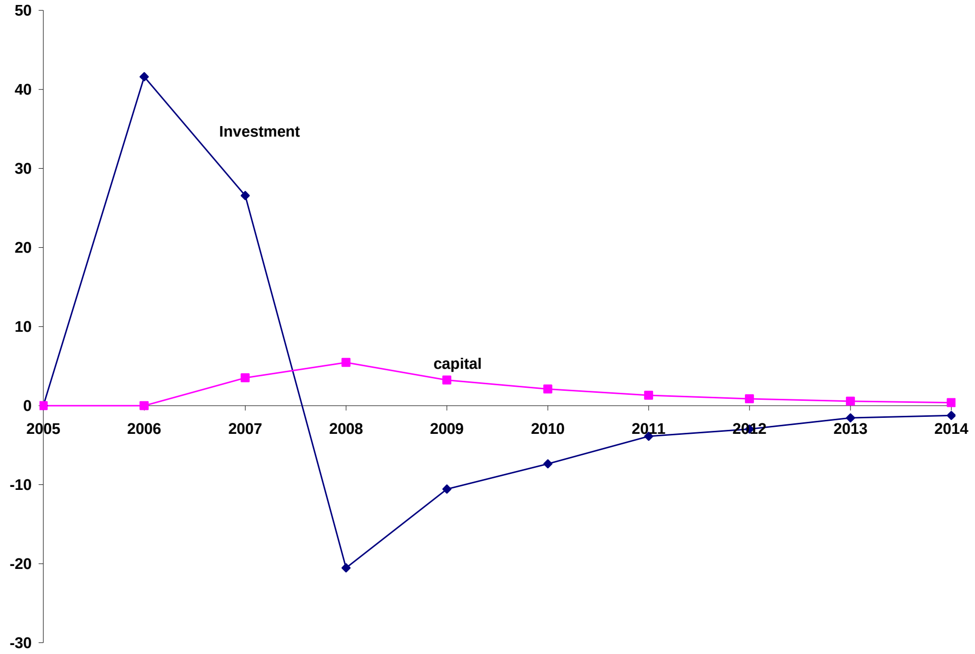


Chart 1.2. Exuberance in Communications & Technology followed by normality: Aggregate investment and capital (% deviation from basecase)

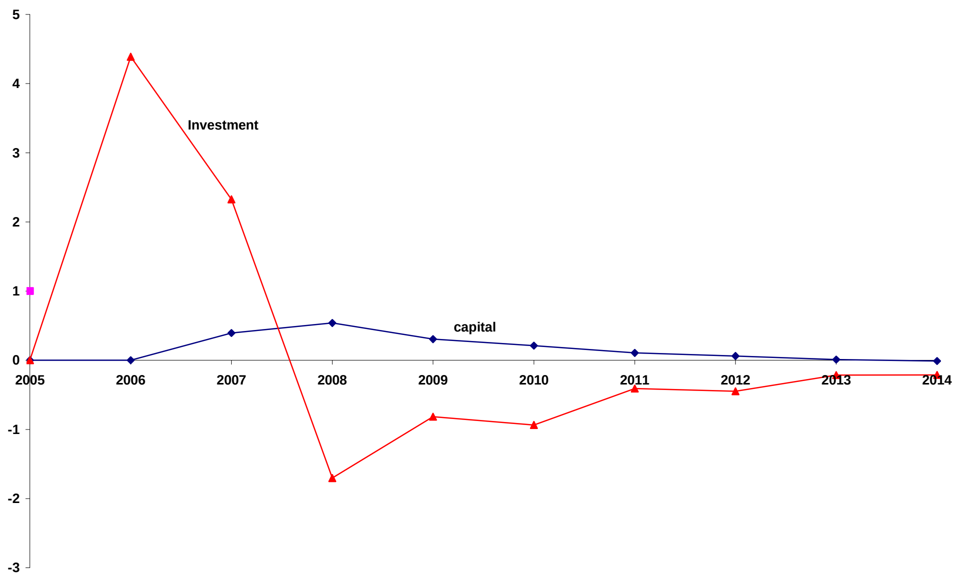


Chart 1.3. Exuberance in Communications & Technology followed by normality: GDP and aggregate labour and capital (% deviation from basecase)

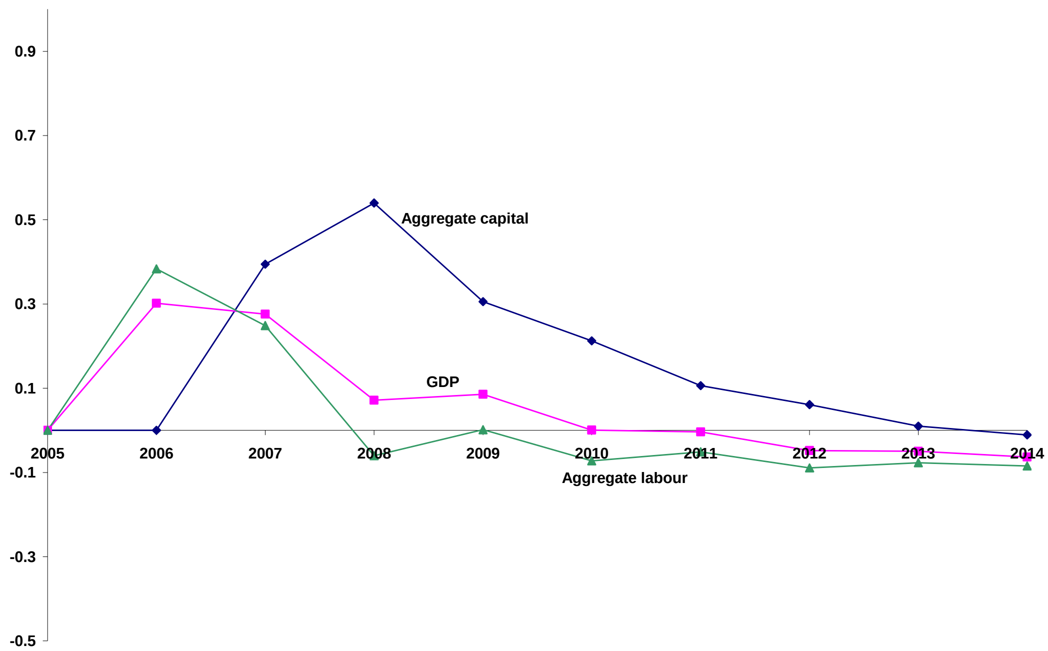


Chart 1.4. Exuberance in Communications & Technology followed by normality: Real wage and aggregate employments (% deviation from basecase)

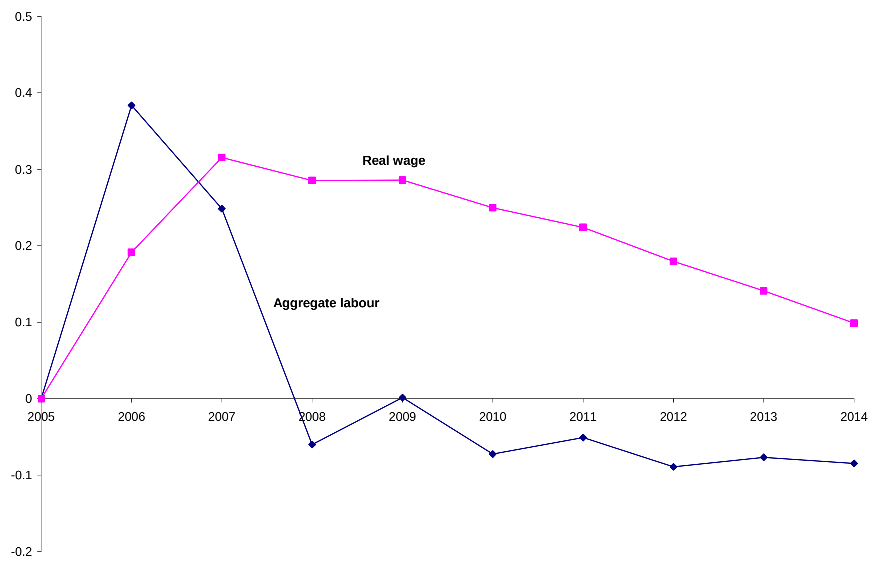


Chart 1.5. Exuberance in Communications & Technology followed by normality: GDP and expenditure-side aggregates (% deviation from basecase)

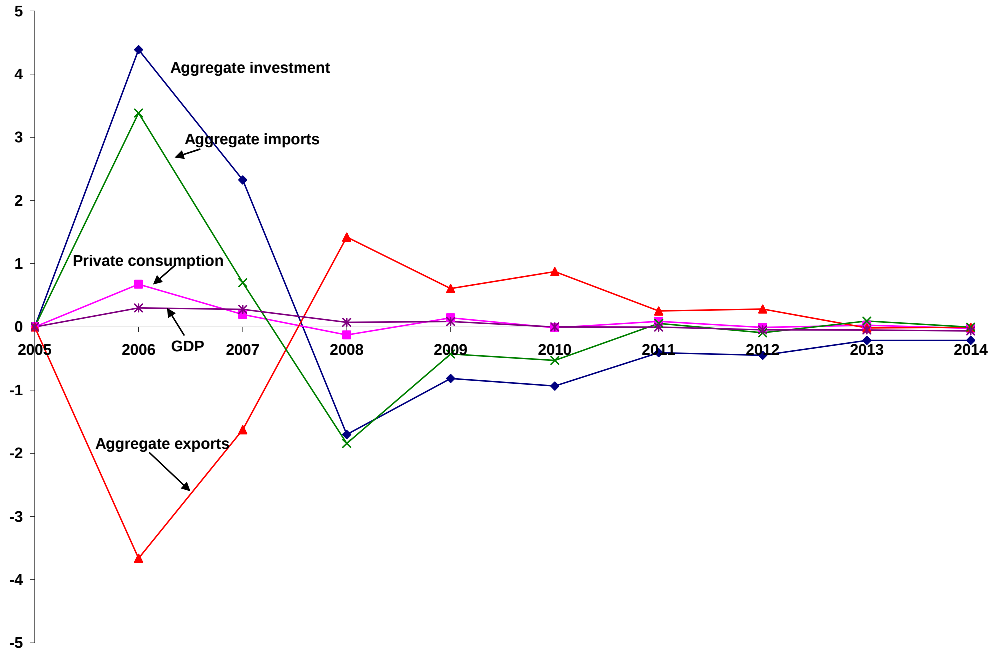


Chart 1.6. Exuberance in Communications & Technology followed by normality: The terms of trade and the exchange rate (positive means appreciation) (% deviation from basecase)

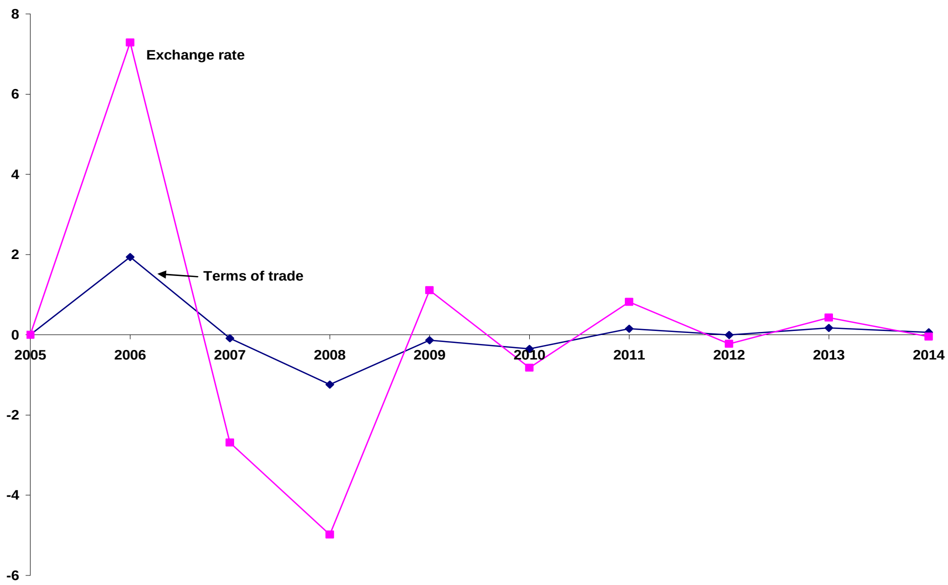
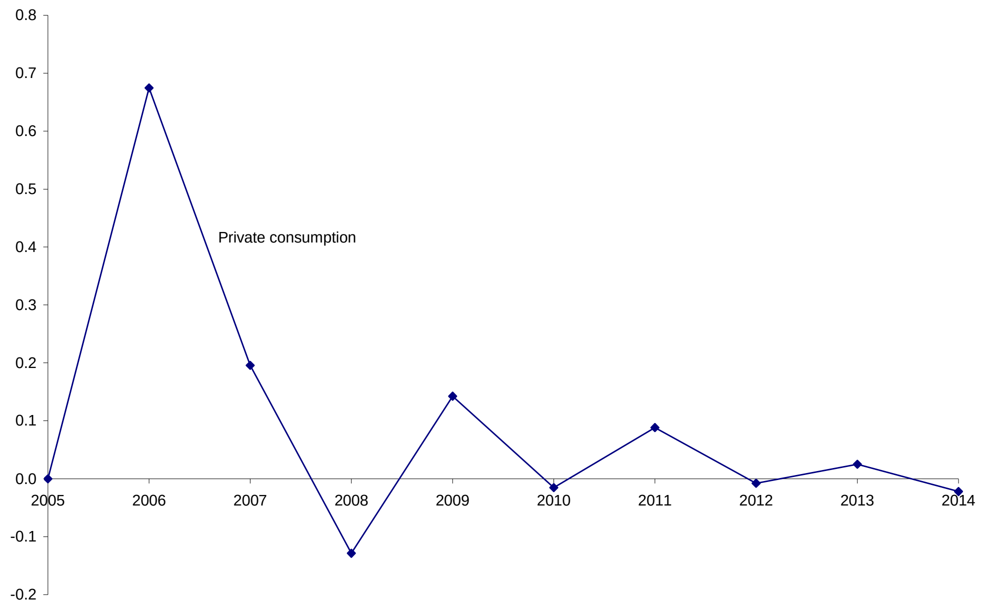


Chart 1.7. Exuberance in Communications & Technology followed by normality: Private consumption (% deviation from basecase)



Simulation 2: Exuberance and capital wastage in Communications and Technology followed by return of expectations to normality

Comparison of results from simulation 2 with those from simulation 1 shows the effects of wasting the extra capital put in place in 2006 and 2007 in the Communications and Technology industries. The first two years in Chart 2.1 look similar to those in Chart 1.1. Beyond 2007, investment in Communications and Technology is close to control. There wasn't any build up of usable capital in the first two years. Consequently the two industries cannot save on investment in the later years.

Chart 2.2 is the macro version of Chart 2.1. There is a small positive deviation in aggregate capital in 2007 despite the wastage of capital in the Communication and Technology industries. This reflects the benefit to the U.S. economy of the terms-of-trade improvement associated with increased investment in the early years. For understanding this, it is helpful to write the marginal productivity condition for capital as:

$$\frac{R}{P_i} = \left(\frac{P_g}{P_i}\right) * MPK\left(\frac{K}{L}\right) \qquad (4)$$

where

R is the rental per unit of capital;

P_i is the price of investment goods;

P_g is the price of GDP, that is the price of goods produced in the U.S.; and

MPK is the marginal product of capital which is a function of K/L.

As explained for simulation 1, the positive deviation in aggregate investment in 2006 improves the terms of trade. This causes an increase in P_g relative to P_i. In addition, the terms-of-trade improvement increases employment in the short run (as explained for simulation 1) thereby increasing the marginal product of capital. Thus, via (4), we see that rentals increase relative to the replacement cost of capital with a resulting increase in investment and capital across the economy.

In Chart 2.3, the employment effect in 2006 is similar to that in Chart 1.3. For the next few years the employment effects in Chart 2.3 are less positive or more negative than those in Chart 1.3. This reflects the lower capital stock in simulation 2 compared with simulation 1. Towards the end of the simulation period, employment is less negative in simulation 2 than in simulation 1. In simulation 2, capital stock is rising at the end of the simulation period, exerting a positive influence on employment, whereas in simulation 1 it was falling, exerting a negative influence on employment.

Chart 2.7 compares the consumption deviations from simulation 2 with those from simulation 1. Capital wastage imposes a cost on U.S. households. In simulation 2 the consumption deviations (using a 5 per cent discount rate) are equivalent to a one off loss of 0.4 per cent. In simulation 1, the consumption deviations were equivalent to a one off gain of 0.9 per cent. Thus capital wastage imposes a once-off loss of 1.3 per cent of consumption.

Why does capital wastage impose a loss on households equivalent to about 1.3 per cent of a year's consumption? Inspection of the simulation results shows that the wasted capital in simulation 2 is worth about \$150 billion. Only about 82 per cent of this belongs to U.S. residents. Thus the wastage of capital belonging to U.S. residents is worth about \$123 billion. With private consumption in the U.S. being about \$8739 billion in 2006, we would expect the capital wastage to ultimately impose a loss in consumption of about 1.4 per cent, closely in line with our result of 1.3 per cent.

Chart 2.1. Exuberance and wastage in Com & Tech followed by normality: Investment and capital in Communications and Technology industries (% deviation from basecase)

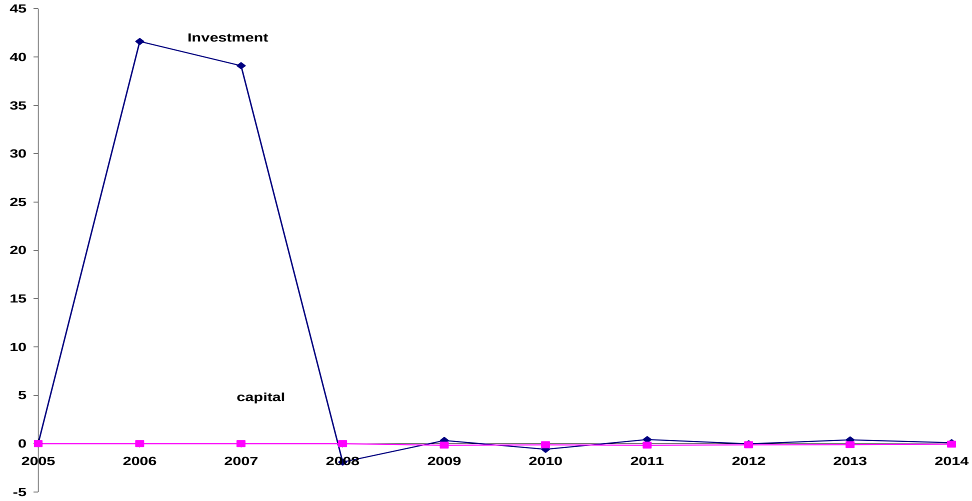


Chart 2.2. Exuberance and wastage in Com & Tech followed by normality: Aggregate investment and capital (% deviation from basecase)

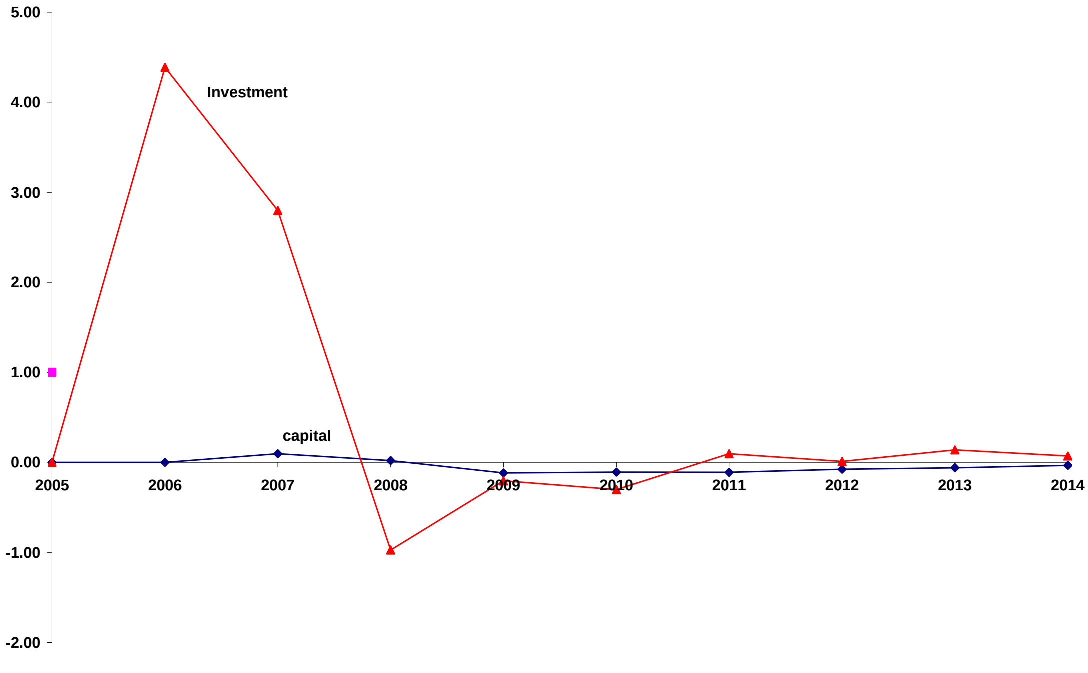


Chart 2.3. Exuberance and wastage in Com & Tech followed by normality: GDP and aggregate labour and capital (% deviation from basecase)

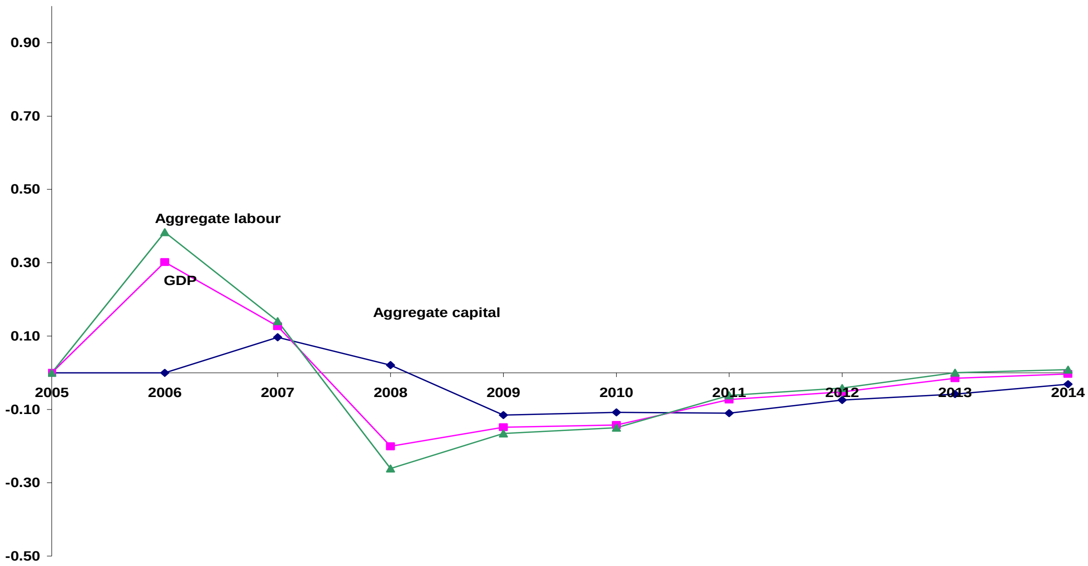


Chart 2.4. Exuberance and wastage in Com & Tech followed by normality: Real wage and aggregate employment (% deviation from basecase)

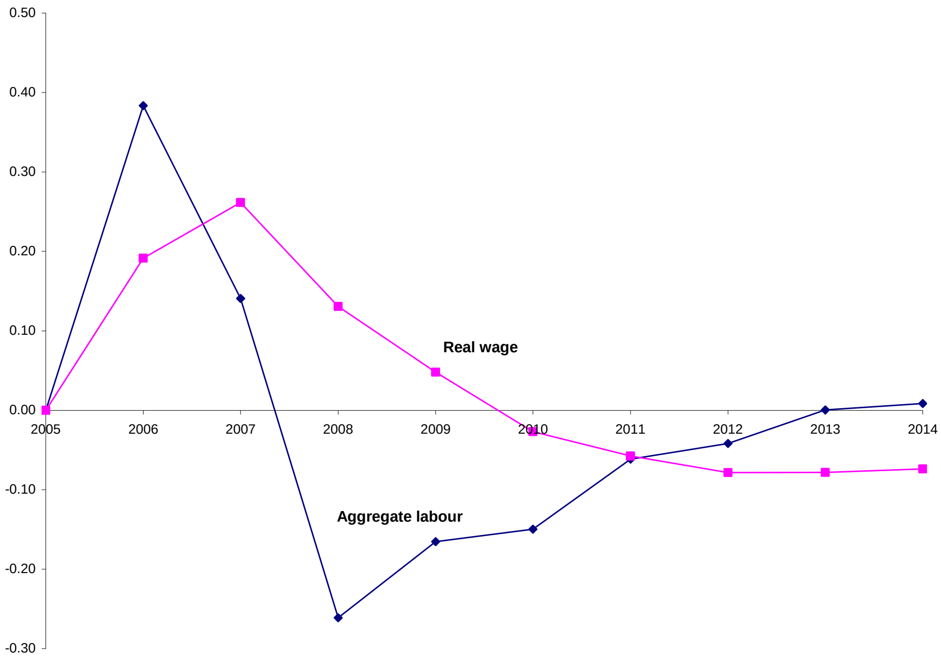


Chart 2.5. Exuberance and wastage in Com & Tech followed by normality: GDP and expenditure-side aggregates (% deviation from basecase)

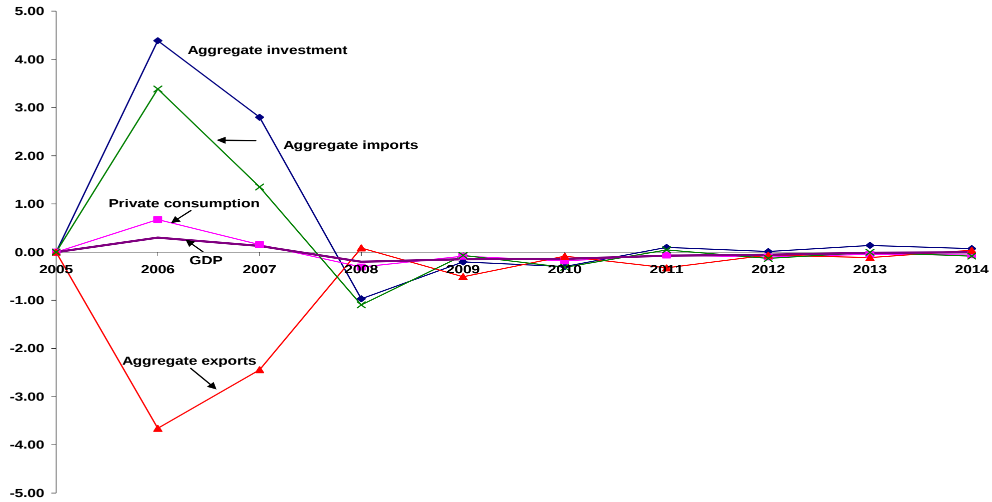


Chart 2.6. Exuberance and wastage in Com & Tech followed by normality: The terms of trade and the exchange rate (positive means appreciation) (% deviation from basecase)

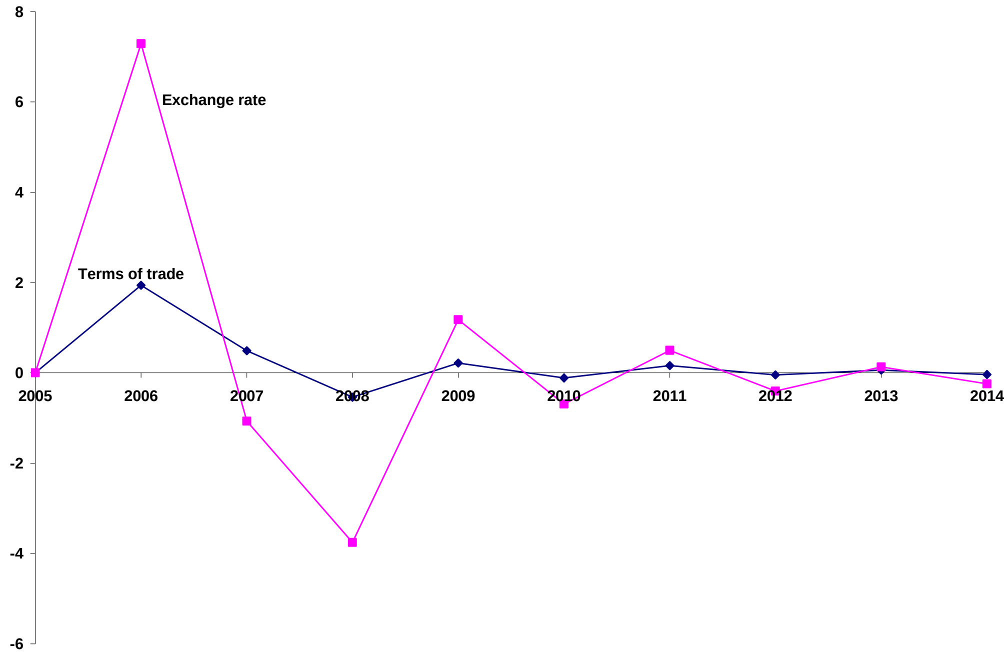
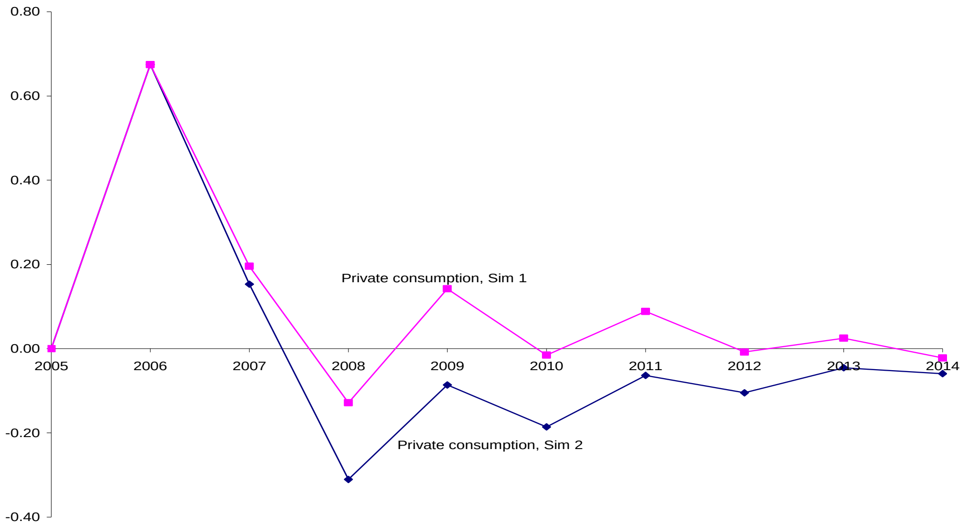


Chart 2.7. Comparison of private consumption in simulations 1 and 2 (% deviation from basecase)



Simulation 3: Exuberance and capital wastage in Communications and Technology followed by general and permanent pessimism

The results for 2006 and 2007 in this simulation are the same as those in simulation 2. Beyond 2007 the results are dominated by the assumption of generalised pessimism. This causes aggregate investment in 2008 to fall about 20 per cent below control (Chart 3.2), generating a sharp decline in the exchange rate (Chart 3.6). Exports are stimulated (Chart 3.5) and the terms of trade fall (Chart 3.6). The decline in the terms of trade causes employment to fall, about 3 per cent below control in 2008 (Chart 3.4). Decline in real wages eventually allows employment to return to control. As shown in Chart 3.7, there is a considerable cost in terms of lost consumption. The deviations in private consumption (using a 5 per cent discount rate) are equivalent to a permanent loss of about 1.6 per cent.

Chart 3.1. Exuberance and wastage in Com & Tech followed by pessimism: Investment and capital in Communications and Technology industries (% deviation from basecase)

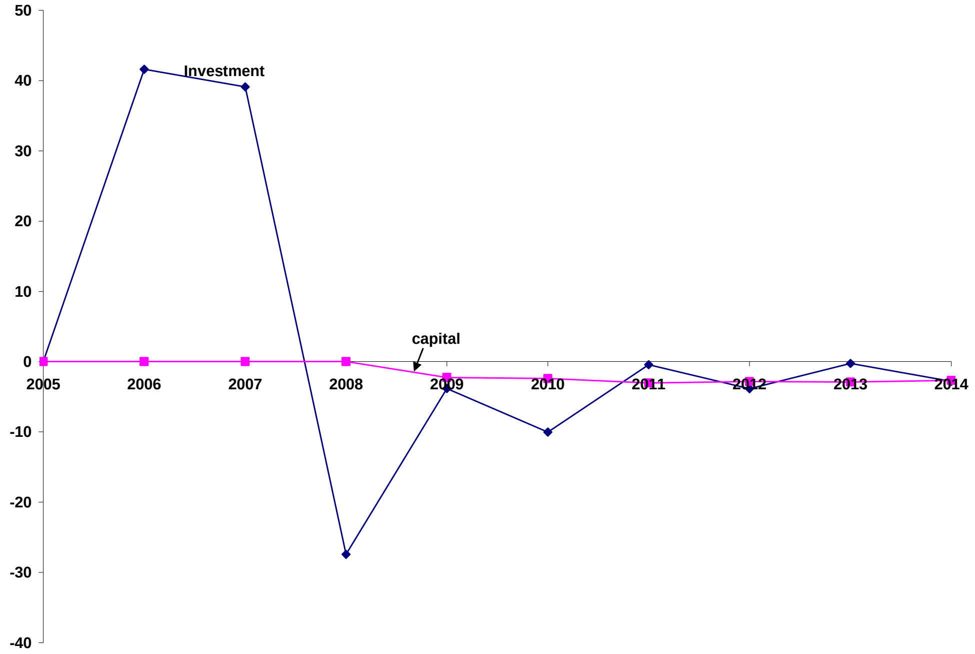


Chart 3.2. Exuberance and wastage in Com & Tech followed by pessimism: Aggregate investment and capital (% deviation from basecase)

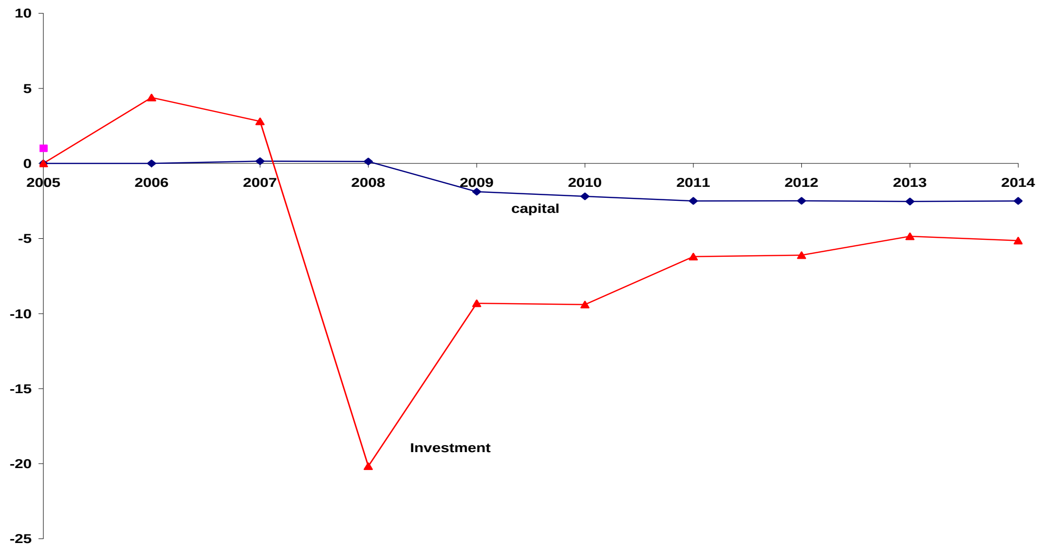


Chart 3.3. Exuberance and wastage in Com & Tech followed by pessimism: GDP and aggregate labour and capital (% deviation from basecase)

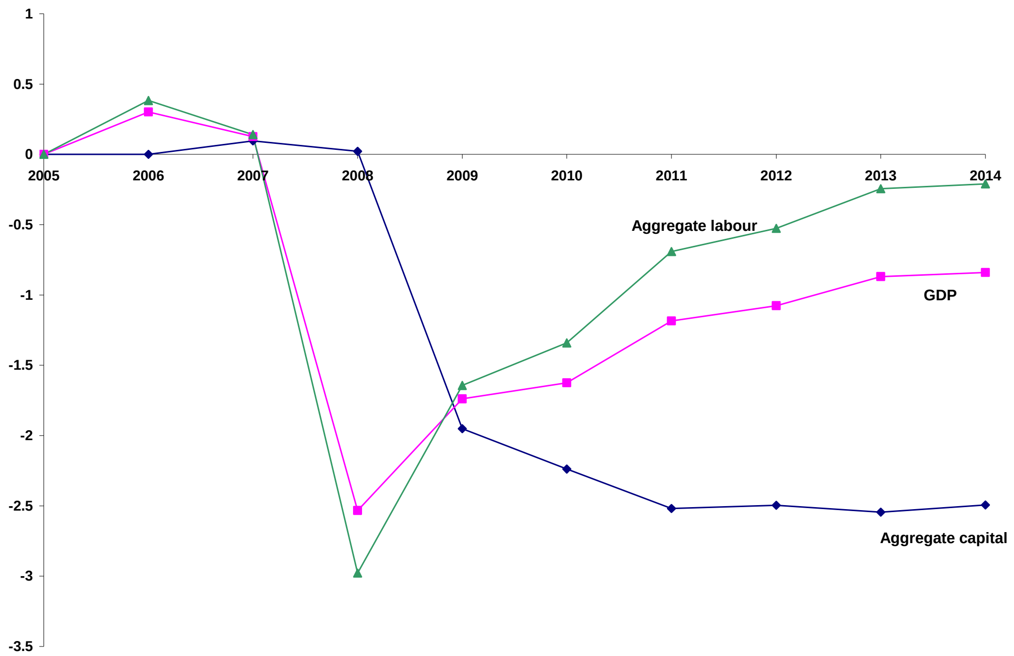


Chart 3.4. Exuberance and wastage in Com & Tech followed by pessimism: Real wage and aggregate employment (% deviation from basecase)

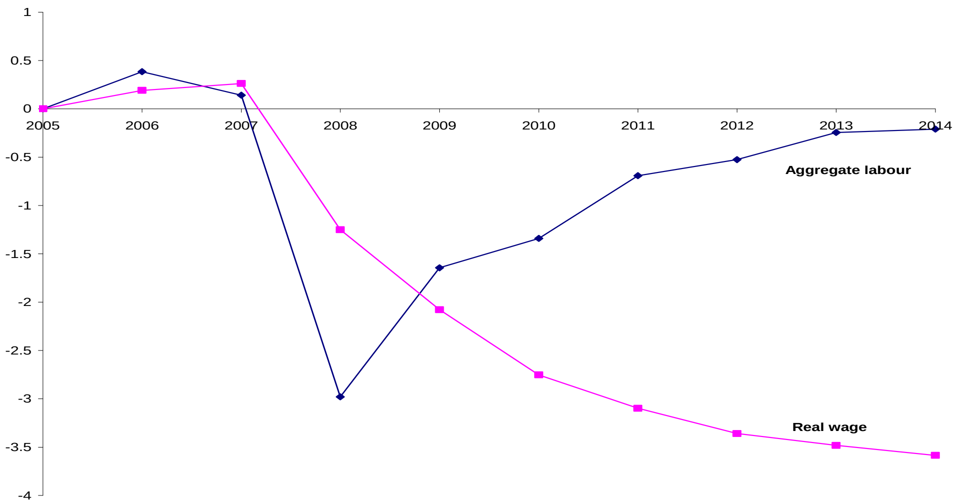


Chart 3.5. Exuberance and wastage in Com & Tech followed by pessimism: GDP and expenditure-side aggregates (% deviation from basecase)

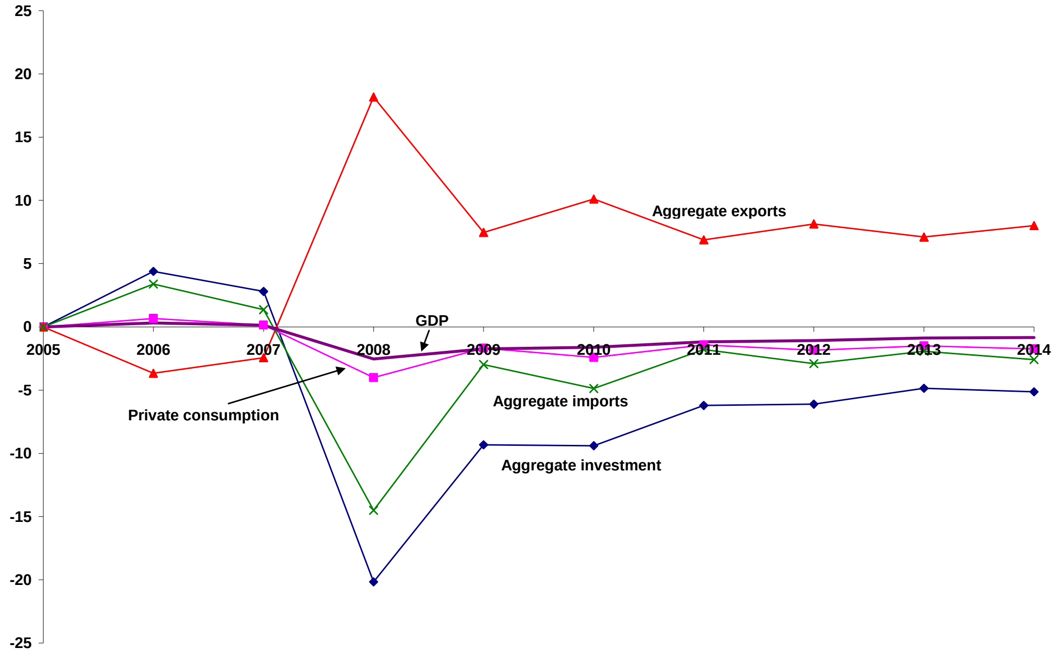


Chart 3.6. Exuberance and wastage in Com & Tech followed by pessimism: The terms of trade and the exchange rate (positive means appreciation) (% deviation from basecase)

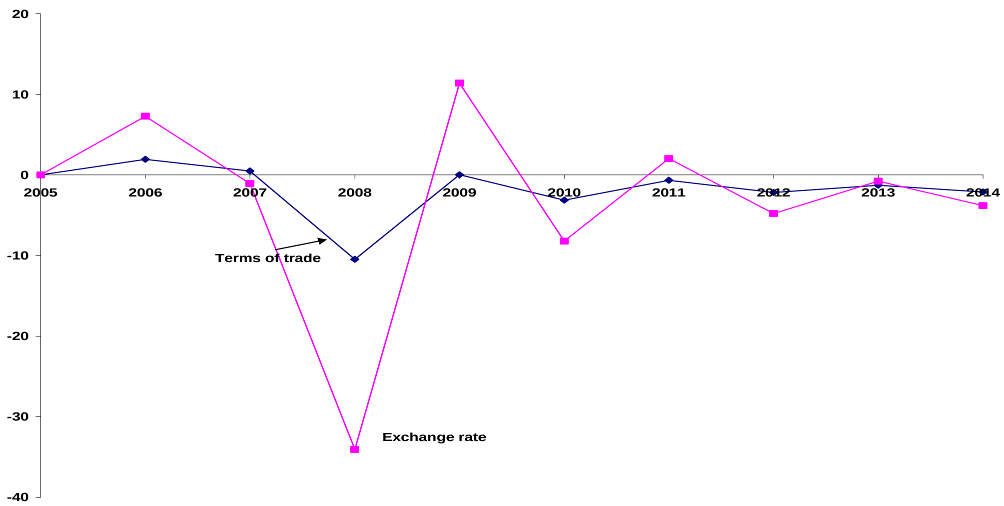
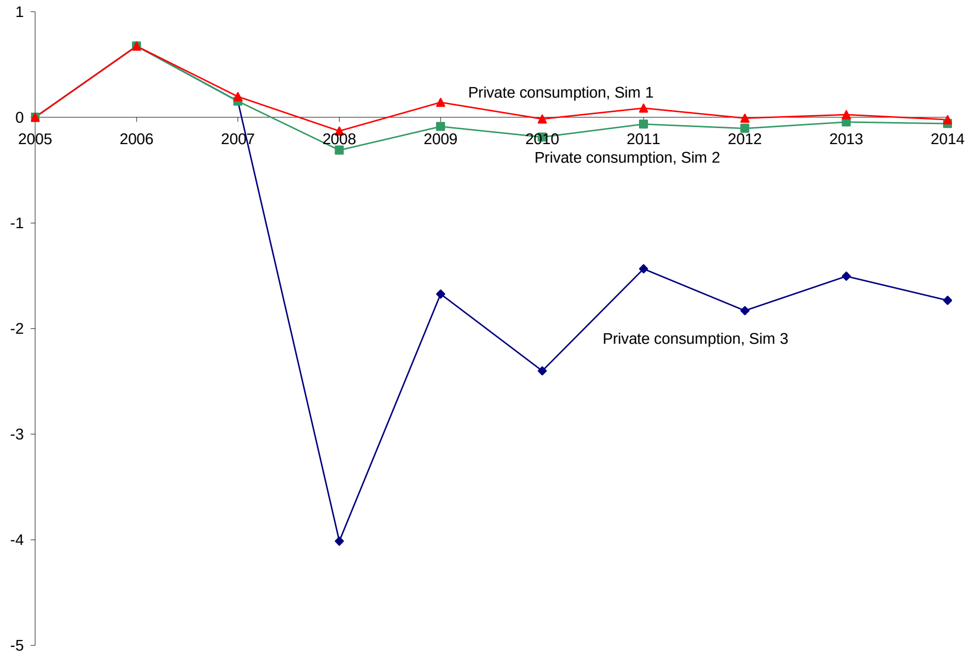


Chart 3.7. Comparison of private consumption in simulations 1, 2 and 3 (% deviation from basecase)



5 Conclusion

This paper has examined the impact of stock market mispricing in the US economy abstracting from the response of the monetary authorities, or from the impact of asymmetric information in the financial sector. The impact of this mispricing depends to a great extent upon the presence or otherwise of distortions in the whole economic system.

As our review of the literature demonstrates, aligning assets with their fundamental values will necessarily always improve welfare, because of the possibility of other distortions in the economic environment. The approach of this paper is to face the implications of the theory of the second best head-on, by using a full scale model of the US to calculate the welfare costs of bubbles numerically.

Modeling allows – indeed requires – that one stipulate any externalities. As it happens, the USAGE model has an investment externality, whereby the exchange rate appreciation leads to an improvement in the terms of trade. Such an externality is subject to the full set of worldwide demand and supply elasticities, and the condition of the cycle overseas, but it is not implausible.

If the investment of the bubble is wasted, the model generates a loss borne by consumers, equivalent to just over one per cent of consumption. However, in a Keynesian fashion, the spending need not be productive to stimulate activity and (as we have just noted) improve the terms of trade.

By experimenting with economy-wide pessimism following the bursting of the bubble, which is a stylised way of representing financial distress, we have demonstrated that a mild capital strike (associated with only a one-half of a percentage point decline in q) can have large negative consumption costs if it is widespread and long-lived.

The analysis in this paper emphasises that our findings not in fact depend upon the spectacular swings in prices associated with bubbles, though it has been natural to speak in this way. We have deliberately kept the magnitude of our shocks to q small (no more than one standard deviation) to make the point that the capital market might be mis-priced for extensive periods. While this may not be as newsworthy as, say, the Subprime mortgage crisis, it does not follow that the consumption losses are trivial.

Finally, we should remind the reader that the costs that we measure are the aggregate of all such costs that are associated with the bubble and its aftermath. We have yet to complete the work that decomposes this aggregate costs into that associated with any misallocation attributable to the mispricing in markets and that attributable to any disruption in the capital markets.

Bibliography

Barlevy, Gadi (2007) “Economic Theory and Asset Bubbles”, Economic Perspectives, Vol. 31, No. 3. Available at SSRN: http://ssrn.com/abstract=1012865

Chirinko, Robert S. and Huntley Schaller, (1996) ‘Business fixed investment and bubbles: the Japanese case’, American Economic Review, Vol. **91,** pp. 663–680.

Diamond, Peter, (1965) “National debt in a neoclassical growth model,” American Economic Review, Vol. 55, No. 5, pp. 1126–1150.

Diba, Behzad T. and Herschel I. Grossman (1987) ‘On the inception of rational bubbles’, Quarterly Journal of Economics, Vol. 87, pp.697–700.

Diba, Behzad T. and Herschel I. Grossman (1988a) ‘The theory of rational bubbles in stock prices’, The Economic Journal, Vol. 98, pp. 746–754.

Diba, Behzad T. and Herschel I. Grossman (1988b) ‘Explosive rational bubbles in stock prices?’, American Economic Review, Vol. 78 (June), pp. 520–530.

Dixon, Peter and Maureen Rimmer (2002), ‘Dynamic General Equilibrium Modeling for Forecasting and Policy: A Practical Guide and Documentation of MONASH’, Centre for Policy Studies, Monash University, Elsevier, Amsterdam.

Dixon, P.B., K.R. Pearson, M.R. Picton and M.T. Rimmer (2005), “Rational expectations for large CGE models: a practical algorithm and a policy application”, *Economic Modelling*, Vol. 22(6), December, pp.1001-1019.

Dixon, P.B., S. Osborne and M.T. Rimmer (2007), “The economy-wide effects in the United States of replacing crude petroleum with biomass”, *Energy and Environment,* 18(6), pp. 709-72.

Dixon, P.B. M. Johnson and M.T. Rimmer (2008), "Reducing illegal migrants in the U.S.: a dynamic CGE analysis", paper presented at the 11th Annual GTAP Conference, Helsinki, Finland, June, pp. 61,available at https://www.gtap.agecon.purdue.edu/resources/download/3734.pdf .

Osborne, S. (2007), "Energy in 2020: Assessing the economic effects of commercialization of cellulosic ethanol", *Office of Competition and Economic Analysis, International Trade Administration, U.S. Department of Commerce*, November, pp.19, available at http://trade.gov/media/publications/pdf/cellulosic2007.pdf .

Eatwell, John, Murray Milgate, and Peter Newman, (eds.) (1987) The new Palgrave: A dictionary of economics, Stockton Press, New York.

Frankel, J. A. and A. K. Rose (1995). Empirical Research on Nominal Exchange Rates. Handbook of International Economics. G. M. Grossman and K. Rogoff. Amsterdam, Elsevier. **3:** 1689-1729.

Froot, Kenneth A. and Maurice Obstfeld (1991) 'Intrinsic bubbles: the case of stock prices', American Economic Review, Vol. 81 (December), pp. 1189–1214.

Grossman, Gene and Noriyuki Yanagawa, (1993) "Asset bubbles and endogenous growth", Journal of Monetary Economics, Vol. 31, No. 1, pp. 3–19.

Gürkaynak, Refet S. (2008) 'Econometric tests of asset price bubbles: Taking stock', Journal of Economic Surveys, Vol. 22, No. 1, pp. 166–186.

International Monetary Fund (2000) 'Asset Prices and the Business Cycle', in World Economic Outlook, World Economic and Financial Surveys Series, pp. 77-111. Available at: http://www.imf.org/external/pubs/ft/weo/2000/01/index.htm

Kindleberger, Charles, P. (2000) Manias, Panics and Crashes: A history of financial Crises, fifth edition, John Wiley & Sons Inc, Hoboken, New Jersey.

Laeven, L. and Valencia, F. (2008) Systemic Banking Crises: A New Data Base. IMF Working Paper WP/08/224).
Available at: http://www.imf.org/external/pubs/ft/wp/2008/wp08224.pdf

Lipsey R.G. and Lancaster, K. (1956), The General Theory of Second Best, *The Review of Economic Studies*, Vol. 24, No. 1. pp. 11-32.

Mishkin, Frederic and Eugene White (2002) 'U.S. stock market crashes and their aftermath: implications for monetary policy', NBER Working Paper No. 8992.

Oliver, Jacques (2000) "Growth-enhancing bubbles," International Economic Review, Vol. 41, No. 1, February, pp. 133–151.

Posen, Adam S., (2006) 'Why central banks should not burst bubbles?', Institute for International Economics Working Paper No. 06-1. Available at SSRN: http://ssrn.com/abstract=880450

Saint-Paul, Gilles (1992) "Fiscal policy in an endogenous growth model," Quarterly Journal of Economics, Vol. 107, No. 4, pp. 1243–1259.

Siegel, Jeremy J. (2003), 'What is an asset price bubble? An operational definition', European Financial Management, Vol. 9, Iss. 1, pp 11–24.

Shiller, Robert J. (1981), 'Do stock prices move too much to be justified by subsequent changes in dividends?', American Economic Review, 71(3), pp 421–436.

Shiller, Robert J. (2003) 'Diverse view on asset bubbles', in WC Hunter, GG Kaufman and M Pomerleano (eds), Asset price bubbles: the implications for monetary, regulatory, and international policies, MIT Press, Cambridge, Mass, pp 35–39.

Simon, John. (2003) "Three Australian Asset-price Bubbles", A chapter in Asset Prices and Monetary Policy, Reserve Bank of Australia, pp. 8-41.

Stiglitz, Joesph E. (1990) 'Symposium on bubbles', The journal of economic perspectives, Vol. 4, No. 2, pp.13-18.

United States International Trade Commission (2004), The Economic Effects of Significant U.S. Import Restraints: Fourth Update 2004, Investigation No. 332-325, Publication 3701, June.

United States International Trade Commission (2007), The Economic Effects of Significant U.S. Import Restraints: Fifth Update 2007, Investigation No. 332-325, Publication 3906, February.

West, Kenneth D. (1987) 'A specification test for speculative bubbles', Quarterly Journal of Economics, Vol. 102, pp. 553–580.

Appendix 1: Description of 'capital supply' functions in MONASH handbook[31]

21.1. Capital-supply functions

In MONASH, the capital-supply function for industry j [f_{jt} in (2.3) and ψ_{KGj} in (16.49)] describes the relationship between j's expected rate of return ($EROR_j$) and the proportionate growth in j's capital stock between the beginning and end of the year [$K\_GR_j = K_+(j)/K(j) - 1$]. MONASH contains two specifications of expected rates of return: static and forward-looking. These will be discussed in the next subsection.

Under both specifications, expected rates of return in year t are composed of two parts:

$$EROR_j = EQEROR_j + F\_EROR\_J_j, - F\_EROR + DIS_j \qquad (21.1)$$

where

$EQEROR_j$ is the equilibrium expected rate of return in industry j, i.e., the expected rate of return required to sustain indefinitely the year-t rate of capital growth in industry j; and

DIS_j is a measure of the disequilibrium in j's expected rate of return in year t, set to zero in this paper.
$F\_EROR\_J_j$, is a shock to expectations about industry j

F_EROR, is a shock to expectations generally.

As illustrated by the AA′ curve in Figure 21.1, we specify the equilibrium expected rate of return in industry j as an inverse logistic function of the proportionate growth in j's capital stock:

$$EQEROR_j = RORN_j$$
$$+ (1/C_j)*[\ln(K\_GR_j - K\_GR\_MIN_j) - \ln(K\_GR\_MAX_j - K\_GR_j)$$
$$- \ln(TREND\_K_j - K\_GR\_MIN_j) + \ln(K\_GR\_MAX_j - TREND\_K_j)]. \qquad (21.2)$$

In this equation,

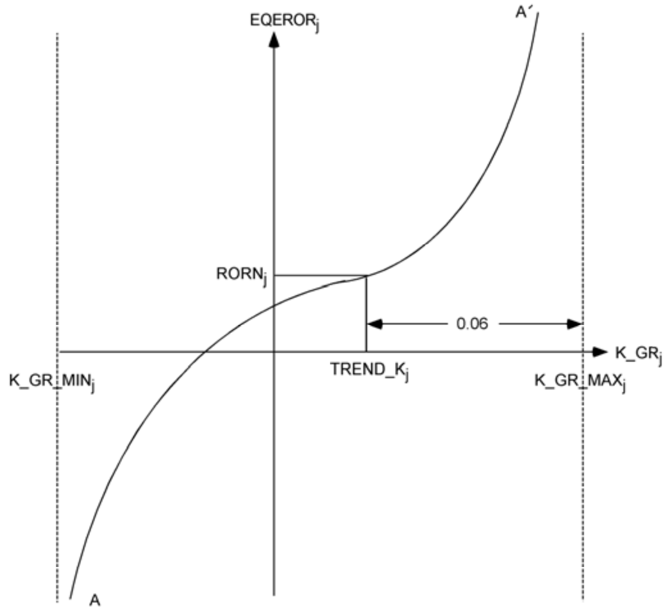
$K\_GR\_MIN_j$ is the minimum possible rate of growth of capital and is set at the negative of the rate of depreciation in industry j.

$TREND\_K_j$ is the industry's historically normal capital growth rate. This is an observed growth rate in capital over an historical period. Its value is data.

$K\_GR\_MAX_j$ is the maximum feasible rate of capital growth in industry j. In recent applications of MONASH, we have avoided unrealistically large simulated growth rates for capital and investment by setting $K\_GR\_MAX_j$ as

Figure 21.1. The equilibrium expected rate of return schedule for industry j, assuming $F\_EROR\_J_j$ and F_EROR are zero

[31] Appendix 1 closely follows Dixon and Rimmer (2002) and we keep their equation numbers and pro-numerals for comparison. The departures are: all F_ERROR variables are removed together with their discussion, and RALPH is zero. See Dixon and Rimmer for details, and references.



$TREND\_K_j$ plus 0.06. Thus, for example, if the historically normal rate of capital growth in an industry is 3 per cent, we impose an upper limit on its simulated capital growth in any year t of 9 per cent.

C_j is a positive parameter the setting of which is discussed below.

$RORN_j$ is the industry's historically normal rate of return. The values of $RORN_j$ are data. For each industry j, $RORN_j$ is an estimate of the average rate of return that applied over the historical period in which the industry's average annual rate of capital growth was TREND_K(j).

$F\_EROR\_J_j$ and F_EROR allow for vertical shifts in the capital supply curves (the AA′ curves in Figure 21.1).

To Explain, (21.1) and (21.2) mean that for industry j to attract sufficient investment in year t to achieve a capital growth rate of $TREND\_K_j$, it must have an expected rate of return of $RORN_j$. For the industry to attract sufficient investment in year t for its capital growth to exceed $TREND\_K_j$, its expected rate of return must be greater than $RORN_j$. Similarly, if the expected rate of return in the industry is less than that observed in the historical period, then provided that there is no disequilibrium, (21.1) and (21.2) imply that investors will restrict their supply of capital to the industry to below the level required to generate capital growth at the historically observed rate.

Finally, we consider the evaluation of the parameter C_j in (21.2). In simulations in which (21.2) plays an active role, the sensitivity of j's capital growth to variations in its equilibrium expected rate of return is controlled by the parameter C_j. Our first step in choosing the value for C_j was to note that

$$C_j = \left[\left. \frac{\partial \ EQEROR_j}{\partial \ K\_GR_j} \right|_{K\_GR_j = TREND\_K_j} \right]^{-1} * \left[\frac{K\_GR\_MAX_j - K\_GR\_MIN_j}{(K\_GR\_MAX_j - TREND\_K_j)(TREND\_K_j - K\_GR\_MIN_j)} \right] . \quad (21.3)$$

Formula (21.3) allows us to evaluate C_j if we can assign a value to the reciprocal of the slope of the AA′ curve in Figure 21.1 in the region of $K\_GR_j = TREND\_K_j$.

We have no data for individual industries to give us a basis for such an assignment. However, by looking at the investment functions in Australian macro models[32], we obtained an estimate, denoted by SMURF, of the average value over all industries of the sensitivity of capital growth to variations in expected rates of return. Then, we computed the value of C_j via (21.3) with

$$\left(\frac{\partial \ \text{EQEROR}_j}{\partial \ \text{K\_GR}_j} \Bigg|_{\text{K\_GR}_j=\text{TREND\_K}_j} \right)^{-1} = \text{SMURF} \qquad \text{for all } j \in \text{IND}. \quad (21.4)$$

21.2. Actual and expected rates of return

The MONASH definition of actual rates of return starts with the calculation of the present value ($PV_{j,t}$) of purchasing in year t a unit of physical capital for use in industry j:

$$PV_{j,t} = - \Pi_{j,t} + [Q_{j,t+1}*(1-T_{t+1}) + \Pi_{j,t+1}*(1-D_j)]/[1 + INT_t*(1-T_{t+1})] \qquad (21.5)$$

where

$\Pi_{j,t}$ is the cost of buying or constructing in year t a unit of capital for use in industry j;

D_j is the rate of depreciation;

$Q_{j,t}$ is the rental rate on j's capital in year t, i.e. the user cost of a unit of capital in year t;

T_t is the tax rate applying to capital income in all industries in year t; and

INT_t is the nominal rate of interest in year t.

In this calculation we assume that the acquisition in year t of a unit of physical capital in industry j involves an immediate outlay of $\Pi_{j,t}$ followed in year t+1 by two benefits which must be discounted by one plus the tax-adjusted interest rate $[INT_t*(1-T_{t+1})]$. The first benefit is the post-tax rental value, $Q_{j,t+1}*(1-T_{t+1})$, of an extra unit of capital in year t+1. The second is the value, $\Pi_{j,t+1}*(1-D_j)$, at which the depreciated unit of capital can be sold in year t+1.

To derive a rate of return formula we divide both sides of (21.5) by $\Pi_{j,t}$, i.e., we define the actual[33] rate of return, $ROR\_ACT_{j,t}$, in year t on physical capital in industry j as the present value of an investment of one dollar. This gives

$$ROR\_ACT_{j,t} = -1 + [(1-T_{t+1})*Q_{j,t+1}/\Pi_{j,t} + (1-D_j)*\Pi_{j,t+1}/\Pi_{j,t}]/[1 + INT_t*(1-T_{t+1})] \ . \qquad (21.6)$$

The determination of capital growth and investment in MONASH depends on expected (rather than actual) rates of return. In most simulations, we assume that capital growth and investment in year t depend on expectations held in year t concerning $ROR\_ACT_{j,t}$.

Under static expectations, we assume that investors expect no change in the tax rate (i.e., they expect T_{t+1} will be the same as T_t) and that rental rates (Q_j) and asset prices (Π_j) will increase by the current rate of inflation (INF). Under these assumptions, their expectation ($EROR\_ST_{j,t}$) of ROR_ACT_{jt} is given by

$$EROR\_ST_{j,t} = -1 + [(1-T_t)*Q_{j,t}/\Pi_{j,t} + (1-D_j)]/(1+R\_INT\_PT\_SE_t), \qquad (21.7)$$

where $R\_INT\_PT\_SE_t$ is the static expectation of the real post-tax interest rate, defined by

$$1 + R\_INT\_PT\_SE_t = [1 + INT_t*(1-T_t)]/[1+INF_t] \ . \qquad (21.8)$$

Under forward-looking or rational expectations, we assume that investors correctly anticipate actual rates of returns, i.e., their expectation ($EROR\_FL_{j,t}$) of $ROR\_ACT_{j,t}$ is $ROR\_ACT_{j,t}$.

Appendix 2: Relating the MONASH expected rate of return to Tobin's Q

Our starting point is (21.7) in Appendix 1, where EROR_ST is now written EROR and R_INT_PT_SE is R_INT (as we ignore 'Post Tax' effects).

$$EROR_{j,t} = -1 + [(1-T_t)* Q_{j,t}/\Pi_{j,t} + (1-D_j)]/(1+RINT_t), \qquad (1)$$

In what follows, we will use lower case *q* to denote Tobin's *q*, to avoid confusion with the rental rate. We can define this for industry j (leaving out j for convenience) via the equation:

---

[32] For example, the Murphy model (Powell and Murphy, 1997) and TRYM (Taplin *et al*.,1993).

[33] We use the adjective *actual* to emphasise that here we are defining the outcome for the rate of return, not a prior expectation held about that outcome.

$$q = \frac{Q_{t+1}(1-T)}{\Pi_t(1+INT)} + \frac{Q_{t+2}(1-T)(1-D)}{\Pi_t(1+INT)(1+INT)} + \frac{Q_{t+3}(1-T)(1-D)^2}{\Pi_t(1+INT)(1+INT)^2} + ... \tag{2}$$

In this equation Q is viewed as the present value of the stream of profits flowing from a unit of capital divided by the book value of a unit of capital (note: the book value is historic cost, so Π_t does not grow for future periods). We have made the assumption that the tax, discount and nominal interest rates are constant. If we make the additional assumption that the rental rate grows with (constant) inflation we can write *q* as follows:

$$q = \frac{(1+INF)Q_t(1-T)}{\Pi_t(1+INT)} + \frac{(1+INF)Q_t(1+INF)(1-T)(1-D)}{\Pi_t(1+INT)(1+INT)} + \frac{(1+INF)Q_t(1+INF)^2(1-T)(1-D)^2}{\Pi_t(1+INT)(1+INT)^2} + ...$$

$$= \frac{Q_t(1-T)}{\Pi_t(1+RINT)} + \frac{Q_t(1+INF)(1-T)(1-D)}{\Pi_t(1+RINT)(1+INT)} + \frac{Q_t(1+INF)^2(1-T)(1-D)^2}{\Pi_t(1+RINT)(1+INT)^2} + ...$$

where RINT=INT-INF. This is a geometric progression with ratio (1+INF)(1-D)/(1+INT) ≈ 1-(RINT+D) Summing to infinity we obtain a simplified q.

$$q = \frac{\frac{Q_t(1-T)}{\Pi_t(1+RINT)}}{[1-(1-(RINT+D))]} \approx \frac{Q_t(1-T)}{\Pi_t(RINT+D)} \quad . \tag{3}$$

Hence, after straightforward manipulation we may connect EROR to q.

$$EROR_t = \frac{(RINT+D)}{[1+RINT]}\{q-1\} \tag{4}$$

Appendix 3: Adjustment of exports and imports

Exports

In USAGE policy simulations, exports of commodity i are determined according to the equation:

$$\left(\frac{X_t^p(i)}{X_t^b(i)} - 1\right) = \left(\frac{X_{t-1}^p(i)}{X_{t-1}^b(i)} - 1\right) + \alpha * \left(\frac{PEL_t^p(i) - PE_t^p(i)}{PE_t^b(i)}\right) \quad , \tag{1}$$

where

$X_t^p(i)$ and $X_t^b(i)$ are the quantities of exports of commodity i in year t in the policy and basecase runs;

$PE_t^p(i)$ and $PE_t^b(i)$ are the foreign-currency prices of exports of commodity i in year t in the policy and basecase runs;

α is a positive parameter; and

$PEL_t^p(i)$ is the foreign-currency price on the long-run export demand curve for commodity i in year t in the policy run. This price is determined by

$$PEL_t^p(i) = \left(X_t^p(i)\right)^{1/\eta} * H_t \quad , \tag{2}$$

where

H_t is an exogenous variable reflecting the position of the foreign long-run demand curve for U.S. commodity i; and

η is a negative parameter (the long-run foreign elasticity of demand for U.S. exports of commodity i).

Under (1), foreign demands of U.S. commodity i in policy runs will move further and further above their basecase path whenever foreign willingness to pay, reflected by $PEL_t^p(i)$, is above the actual price, $PE_t^p(i)$. One way to see how this adjustment works is via Figure 1 in which we assume that basecase quantities and prices are one for all years (a steady state) so that (1) simplifies to

$$X_t^p(i) = X_{t-1}^p(i) + \alpha * \left(PEL_t^p(i) - PE_t^p(i)\right) \quad . \tag{3}$$

Assume that the policy causes a once-off movement in year 1 in the U.S. supply curve from S^b to S^p. This would be the sort of shift associated with a permanent appreciation of the U.S. currency.

In Figure 1, DL is a convenient diagrammatic representation of the foreign demand curve for U.S. product i and is a linear version of equation (2). We assume that DL has slope -γ where γ is a positive parameter, so that

$$PEL_t^p(i) - PEL_{t-1}^p(i) = -\gamma * \left(X_t^p(i) - X_{t-1}^p(i)\right) \quad . \tag{4}$$

Combining (3) and (4) we obtain

$$PE_t^p(i) = PEL_{t-1}^p(i) + \beta * \left(X_t^p(i) - X_{t-1}^p(i)\right) \quad . \tag{5}$$

where β is the negative parameter given by $-(\gamma + 1/\alpha)$. Equation (5) defines what we call the short-run demand curve in the policy run for year t. It is represented in Figure 1 for year 1 by the line DS_1. The quantity and price solution in the policy run for year 1 is determined at point 1, the intersection of the policy supply curve, S^p, and the short-run demand curve, DS_1. For year 2, the short-run demand curve, DS_2, is to the left of the short-run demand curve for year 1: it is the straight line with slope β passing through the point $(X_1^p(i), PEL_1^p(i))$, point a in Figure 1. With no further movement in the supply curve, the quantity-price solution for year 2 is at point 2. In the next year the quantity-price solution moves to point 3, eventually arriving at point F.

For a once-off appreciation, Figure 1 implies that the U.S. will experience a significant short-run increase in the foreign-currency prices of its exports and a mild reduction in quantity. Eventually, foreigners find new sources of supply causing quantities to decline and prices to fall back to their initial levels. This sort of adjustment is consistent with the J-curve hypothesis, usually expressed in terms of a devaluation. Under this hypothesis, a devaluation (appreciation) causes little initial quantity increase (decrease) and an adverse (favourable) foreign currency price movement with a net deterioration (improvement) in foreign-currency export earnings. Eventually, however, the devaluation (appreciation) causes a considerable quantity improvement (deterioration) and little change (depending on the slope of the long-run demand curve) in the foreign-currency price. Thus, in the long run, the devaluation (appreciation) normally generates an improvement (deterioration) in export earnings.

Now consider the case in which the appreciation in year 1 is immediately followed by a devaluation in year 2 that returns the supply curve to its basecase position. Then the solution in year 2 is at point 2′. In subsequent years the solution moves up the S^b curve, eventually returning to point 0.

Notice that at point 2′ both the export quantity and price are below their basecase levels despite the exchange rate being at its basecase level. This is the curious result noted in our discussion of simulation 1.

Imports

In USAGE policy simulations, imports of commodity i are determined according to the equation:

$$\left(\frac{M_t^p(i)}{M_t^b(i)}-1\right)=\left(\frac{M_{t-1}^p(i)}{M_{t-1}^b(i)}-1\right)+\delta*\left(\frac{PM_t^p(i)-PML_t^p(i)}{PM_t^b(i)}\right) \quad , \tag{6}$$

where

$M_t^p(i)$ and $M_t^b(i)$ are the quantities of imports of commodity i in year t in the policy and basecase runs;

$PM_t^p(i)$ and $PM_t^b(i)$ are the foreign-currency prices of imports of commodity i in year tin the policy and basecase runs;

δ is a positive parameter; and

$PML_t^p(i)$ is the foreign-currency price on the long-run import supply curve for commodity i in year t in the policy run. This price is determined by

$$PML_t^p(i)=\left(M_t^p(i)\right)^{1/\mu}*G_t \quad , \tag{7}$$

where

G_t is an exogenous variable reflecting the position of the foreign long-run supply curve for commodity i to the U.S.; and

μ is a positive parameter (the long-run foreign elasticity of supply for imports of commodity i to the U.S.).

Under (6), foreign supplies of commodity i to the U.S. in policy runs will move further and further above their basecase path whenever the foreign-currency import price, $PM_t^p(i)$, is above the long-run price, $PML_t^p(i)$, that would elicit the existing supply. One way to see how this adjustment works is via Figure 2 in which we assume that basecase quantities and prices are one for all years (a steady state) so that (6) simplifies to

$$M_t^p(i)=M_{t-1}^p(i)+\delta*\left(PM_t^p(i)-PML_t^p(i)\right) \quad . \tag{8}$$

Assume that the policy causes a once-off movement in year 1 in the U.S. demand curve from D^b to D^p. This would be the sort of shift associated with a permanent appreciation of the U.S. currency.

In Figure 2, SL is a convenient diagrammatic representation of the foreign supply curve for commodity i to the U.S. and is a linear version of equation (7). We assume that SL has slope ε where ε is a positive parameter, so that

$$PML_t^p(i)-PML_{t-1}^p(i)=\varepsilon*\left(M_t^p(i)-M_{t-1}^p(i)\right) \quad . \tag{9}$$

Combining (8) and (9) we obtain

$$PM_t^p(i)=PML_{t-1}^p(i)+\phi*\left(M_t^p(i)-M_{t-1}^p(i)\right) \tag{10}$$

where ϕ is the positive parameter given by (ε + 1/δ). Equation (10) defines what we call the short-run supply curve in the policy run for year t. It is represented in Figure 2 for year 1 by the line SS_1. The quantity and price solution in the policy run for year 1 is determined at point 1, the intersection of the policy demand curve, D^p, and the short-run supply curve, SS_1. For year 2, the short-run supply curve, SS_2, is to the right of the short-run supply curve for year 1: it is the straight line with slope ϕ passing through the point $(M_1^p(i), PML_1^p(i))$, point a in Figure 2. With no further movement in the demand curve, the quantity-price solution for year 2 is at point 2. In the next year the quantity-price solution moves to point 3, eventually arriving at point F.

For a once-off appreciation, Figure 2 implies that the U.S. will experience a significant short-run increase in the foreign-currency prices of its imports and a mild increase in their quantity. Eventually, in response to high foreign-currency prices, new foreign suppliers will emerge causing foreign-currency prices to fall back towards their initial levels and quantities to increase. This sort of adjustment is consistent with the partial pass-through hypothesis, usually expressed in terms of a devaluation. Under this hypothesis, an *x* per cent devaluation (appreciation) causes little initial change in U.S. dollar prices of imports and thus little change in quantities. Foreign-currency prices decrease (increase) by nearly *x* per cent. Eventually, however, the devaluation (appreciation) causes withdrawal (expansion) of supply by foreigners and return of foreign-currency prices towards their initial levels. There is considerable long-run quantity contraction (expansion) and little change (depending on the slope of the long-run supply curve) in the foreign-currency price. Thus, in the long run, the devaluation (appreciation) normally generates a significant decrease (increase) in foreign-currency import payments.

Now consider the case in which the appreciation in year 1 is immediately followed by a devaluation in year 2 that returns the demand curve to its basecase position. Then the solution in year 2 is at point 2′. In subsequent years the solution moves up the D^b curve, eventually returning to point 0.

Notice that at point 2′ the import quantity is above its basecase level despite the exchange rate being at its basecase level. This is the curious result noted in our discussion of simulation 1.

Finally notice from Figures 1 and 2 that a reversed appreciation has an ambiguous effect on the terms of trade in year 2: the foreign-currency prices of both exports and imports are reduced below their basecase levels.

Figure 1. Export price and quantity adjustment

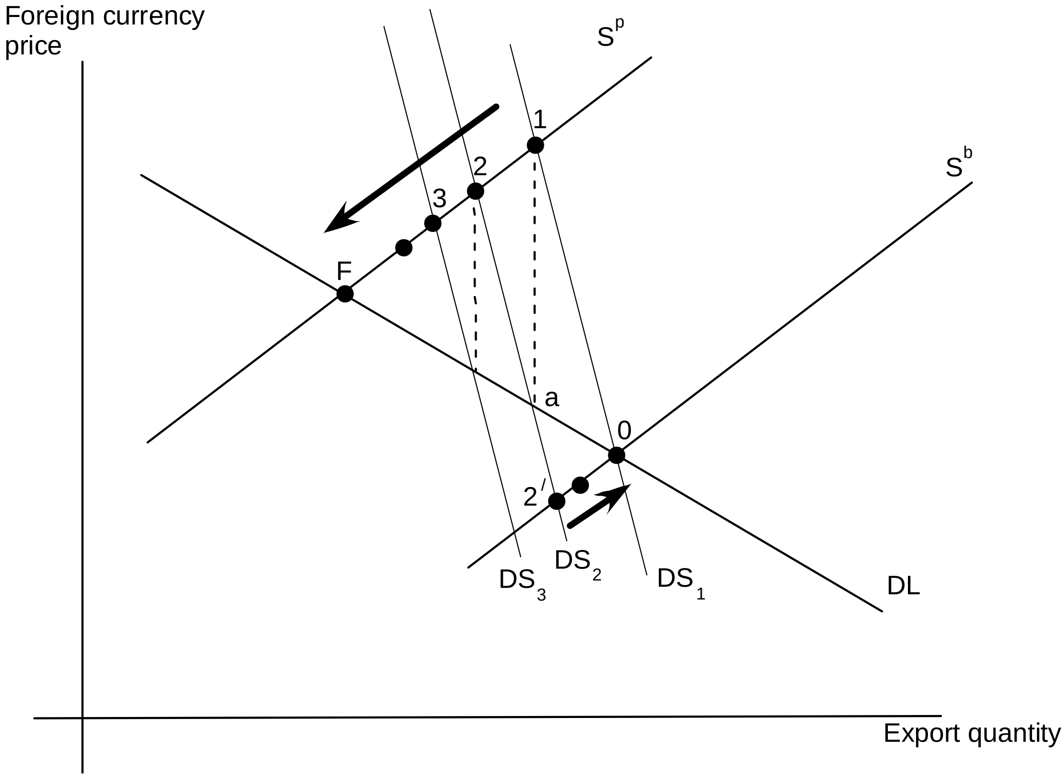


Figure 2. Import price and quantity adjustment