Asset Price Regulators Unite: 
You have Macroeconomic Stability to Win 
and the Microeconomic Losses are Second-order  

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Abstract
The Global Financial Crisis (GFC) has rekindled debate about the desirability of governmental interference in asset markets – either through the operation of policy levers, or, through the chosen institutional setup. In this paper we quantify economic costs due to mispricing of real assets in the USAGE model of the United States. The microeconomic costs of misallocated capital are second-order small. The model suggests that regulators (or central banks) who restrain the volatility of asset prices do so without incurring large economic costs.

JEL Classifications: C50, G01, F41

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**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 over 400 years. The Dutch tulip 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: US Tobin’s q: Industrials, Telecommunications and Technology**

Bubbles are characterized 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.\(^3\)

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

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\(^3\) 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 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).
writ large in many memories. No consensus about the magnitude or inevitability of these effects has emerged (Posen, 2006)\(^4\) though the events of the last few years may forge one.

The blame for the GFC has been shelved home to a housing bubble and there is a prospect of a more interventionist regulatory stance to reduce the likelihood of bubbles in the price of real assets (e.g., housing and equities). These policy prescriptions are informed by the literature on the impact and incidence of mispricing, which we briefly review in section 2. That literature focuses on the micro- and macro-economic mechanisms which can affect the real economy – namely capital misallocation, and, financial sector distress induced by macroeconomic cyclicality.\(^5\) There is no doubt that burst bubbles can leave the economy in a sorry state, so we feel no pressing need to provide model simulations to that effect. Instead, our central claim is that the microeconomic costs of misallocation is relatively unimportant.

1.2 The Argument Advanced for our Central Claim

Our central claim begs an empirical question of how the microeconomic efficiency costs could be quantified. We turn to USAGE, a contemporary policy model of the United States, which is explained in section 3.

The model’s credibility rests partly on its application to contemporary policy issues (US International Trade Commission, 2004 & 2007) and partly because its micro-foundations blunt the critique of Lucas (1976). The immunity from the Lucas critique admittedly comes at a cost of not incorporating realistic policy rules in the simulations. But this seems to us a small price to pay. It is hard to imagine an environment more beset by rapidly evolving policy rules and institutions than the aftermath of the GFC (Goodhart, 2009).

Section 4 advances the central argument of the paper, which proceeds as follows. It might be thought that the unimportance of capital misallocation follows as a consequence of the envelope theorem (section 4.1). That is, small perturbations of capital from an optimal allocation have second order effects. However, in the real world it is not obvious a) if capital is optimally allocated, b) if perturbations to capital are ‘small’ and c) how to

\(^4\) 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. Gürgaynak (2008) provides a comprehensive survey of 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 Obstfeld 1991). After canvassing the strength and weakness of each type of tests, Gürgaynak summed up 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.” (Gürgaynak 2008, p.166)
handle the implications of the theory of the second best (Lipsey and Lancaster, 1956) if capital is in fact not optimally allocated.6

The USAGE model provides a way through these difficulties. We are able to calibrate USAGE to empirical Tobin q’s, and proceed with analysis recognizing the reality that US capital is not optimally allocated. When capital is allowed to move to equalize returns or Tobin’s q, the benefits are second order small (section 4.2), implying that the function relating capital to profits could still be regarded as ‘flat’. Furthermore, a realistic perturbation to a capital-starved sector (Healthcare) in section 4.3 results in a NPV effect that is both negative and small. This suggests respectively that the theory of second best is unimportant practically, and, that the perturbation in capital associated with historic share market volatility can indeed be considered ‘small’. We note the limitations of our argument in Section 5, and conclude.

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 utilizing 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 defense 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

Our rapidly evolving global financial system provides other channels for financial distress to impact on the real economy. As a result of increasing competition and financial deregulation, international financial institutions had, prior to the GFC, aggressively sought income from non-core lines of business, such as asset trading

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6 To quote Lipsey and Lancaster (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 by 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.’

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)
As a consequence of this, they have significantly increased their exposure to the real economy.

Standing in the wake of the GFC, we feel no pressing need for a model simulation to confirm that the macroeconomic consequences of financial fragility are potentially large. What we aim to show is that the model’s microeconomic effects of asset prices are very small – so small that the relative importance of the two channels is not open to doubt.

Mispricings of assets affect the micro-economy by disrupting the optimal allocation of resources. They create price wedges which distort both inter-temporal and cross-sectional investment decisions (Chirinko and Schaller 2007) – creating so-called allocative inefficiency or microeconomic inefficiency.

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 unchanged 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).

The literature descending from Diamond (1965) 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.10 In the particulars of his environment, a bubble is socially beneficial, because it draws resources away from already over-accumulated capital.11 Naturally, as Oliver (2000) points out, bubbles in 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

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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).

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

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

11 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.
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.\textsuperscript{12}

It is not hard to imagine other situations of investment externalities. The difficulties of capturing profits from innovation lead to under-investment of R&I in the economy. A speculative bubble, if it encourages R&I investment, may lead to advantages which at least mitigate the obvious disadvantages of such a bubble.

The model we use assumes away almost all such externalities, since they require industry knowledge at a very detailed level of disaggregation. However, a stock market (or housing) boom in USAGE leads to investment which, in turn, appreciates the real exchange rate. The appreciating US dollar, ceteris paribus, improves the terms of trade. This is an externality because investors do not take this into account when deciding whether to invest.

2.2 Asset Mispricing Happens

Quantifying the effects of mispricing would be ‘academic’, in the bad sense of that word, were it not likely that asset prices often are, in fact, mispriced. As outlined in Barberis and Thaler (2003) limits-to-arbitrage arguments (Shleifer and Vishny 1997) have blunted Friedman’s (1953) assertion that mispricing is always immediately eliminated by arbitrageurs. The risk that ‘noise traders’ take a security further away from its fundamental value, transforms arbitrage – which is riskless by definition – into a highly risky activity.

A beautiful example of this is furnished by Froot and Dabora (1999) who track the relative price of Royal Dutch securities to Shell securities. The unusual nature of these assets – Royal Dutch and Shell securities are each a claim on 60 per cent and 40 per cent of the combined cash flow of the two companies – ensure that the rational relative price ought to be 1.5. Instead, Royal Dutch is sometimes 35 per cent underpriced and sometimes 15 per cent overpriced. Given the features of this natural experiment, the only remaining risk of holding Royal Dutch must be the risk of noise trading.

We need not say any more about these phenomena. Indeed, we cannot, since our tool of choice is a neoclassical Computable-General-Equilibrium (CGE) model. But we will subsequently interpret annual volatility in Tobin’s q as an upper bound on annual volatility of the share market driven by phenomena like noise trading, with limits to arbitrage allowing this mispricing. Even this upper bound does not imply large microeconomic costs, as we shall see.

3 The USAGE Model

3.1 Computable General Equilibrium Models Neutralizes the Lucas Critique

\footnote{12 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 (CGE) 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.).

The version of the model used in this paper lacks a monetary and fiscal authority. Without policy, the model relies upon a pro-cyclical exchange rate to stabilize the economy. That is, 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.

With all the macroeconomic adjustment coming through this channel, the movements in the real exchange rate required to obtain equilibrium are probably larger than in reality. These simulations therefore share a drawback of all macro models that rely on expenditure switching as an equilibrating channel; the relatively poor performance of models of nominal exchange rates (Frankel and Rose 1995).

Nevertheless, a CGE model is the analytic tool least hamstrung during times of structural change and turbulent policy making (Lucas, 1976). The USAGE model is built upon ‘non-policy’ parameters, in contrast to models that are driven by historically estimated specifications of policy rules. Indeed, it was precisely times such as these (eg. the turbulent 1970s) which spawned the development of CGE models in the first place.

3.2 General Structure

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.

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.

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

14 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 shocks do not effect on technology or household preferences.
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 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 endogenization 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 exogenized 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.

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.

In what follows, we show the microeconomic costs of misallocation are small. For comparison, we now outline a stylized macroeconomic ‘burst bubble’ scenario. Investors hold overly optimistic expectations as to the returns that will be generated by investing in the Telecommunication and Technology industries. Tobin’s q is higher in both sectors by one standard deviation over two years. However, the additional investment that flows from these unrealistic expectations is completely wasted; it does not add to the capital stock. An extended period of pessimism follows (three or five years), where investors under-estimate the returns that will be generated across all firms. We model this as a ‘capital strike’, where Tobin’s q is one-half of one standard deviation lower across the
whole economy. In Figure 2 we give the losses to the economy in terms of the net present value (NPV) of forgone consumption and GDP.

**Figure 2: NPV of GDP and Consumption Deviations**

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>One-off %C NPV</th>
<th>One-off %GDP NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two year boom followed by 3 year pessimism</td>
<td>-6.5</td>
<td>-4.4</td>
</tr>
<tr>
<td>Two year boom followed by 5 year pessimism</td>
<td>-8.9</td>
<td>-6.0</td>
</tr>
</tbody>
</table>

These simulations are not intended to be anything other than ‘back of the envelope’ calculations, since the pessimism is exogenously imposed by shocking Tobin’s q. What they do demonstrate, however, is that movements in q of a historically reasonable magnitude (far smaller than the q swings in housing associated with the GFC) could generate large losses to the economy. Capital decumulation holds back growth, and, the Mundell-Fleming investment/exchange rate nexus superimposes a demand cycle over the lowered trend in aggregate supply. In what follows, capital is held fixed, shutting down both macroeconomic channels.

4 The Relative Unimportance of Capital Misallocation

4.1 Theoretical Benchmark

It might be thought that the envelope theorem is sufficient to assure the main claim of this paper. To see how, consider the allocation of capital to a single industry.

Assume that there is a distribution of capital (K) around the optimal allocation, κ. For simplicity let $K \sim N(\kappa, \sigma^2)$. We assume that the firm attempts to maximize profits, $\pi$, by choosing $K$ to satisfy $\frac{\partial \pi}{\partial K} = 0$ and gets this right on average. This is equivalent to being in the neighbourhood of the maximum of a surface relating capital to profits $\pi(K)$.

We want to know the conditions under which the departures from optimality will not matter very much for the firm. Equivalently, we want to know when the variance of $\pi$ resulting from variation in $K$, $\sigma^2$, will not be large. Algebraically, we work out the variance of $\pi$ where $K$ is in the neighbourhood of $\kappa$.

$$\pi(K) = \pi(\kappa) + \pi'(\kappa)(K - \kappa) + \frac{\pi''(\kappa)}{2}(K - \kappa)^2$$

(1)

Then, we take the variance.

$$V[\pi(K)] = [\pi'(\mu)]^2 \sigma^2 + \left(\frac{\pi''(\mu)}{2}\right)^2 \sigma^4$$

(2)

Equation (2) restates the envelope theorem. If $\pi' = 0$, and if the profit function is close to linear at the optimum ($\pi''$ approaches zero) then the effects of $\sigma^2$ are vanishingly small and perturbations in capital are unlikely to matter for profits. Informally, if the profit function is ‘flat’ relative to the size of volatility in capital, the costs and the final impact on profits are low. Figure 3, we see why the ‘flat’ profit function compresses the volatility in profits. The distributions are shown in grey.
Figure 3: Misallocated Capital and Profits

To understand Figure 3, one takes imaginary draws from the bell-shaped distribution on the left of the horizontal axis, and traces them through to the profit function (we have done so with one draw from the tail and one at the mean). Figure 3 and (2) suggest that optimal allocations across all industries would be sufficient to guarantee a small effect were capital to be misallocated by ‘small’ amounts, due to the envelope theorem.15

In the real world, however, capital is not optimally allocated (Figure 4), so the Theory of the Second Best (Lipsey and Lancaster, 1956) gives us pause. Furthermore, it is unclear if perturbations to capital are ‘small’. Each concern disarms the envelope theorem.

Non-optimal capital means $\pi'$ is non-zero and the variance of $\pi$ could be *even larger* than the variance of $K$. This can be seen from (2), or from sliding the distribution of $K$ close to the origin in Figure 3. If $K$ perturbations are large, the tail draws of $K$ may run into the steep portions of $\pi(K)$ and again the variance of profits may be large. In what follows we adopt the USAGE model to see if the effects of capital misallocation are small given that the returns to capital, and $q$’s, differ across different US industries.16

<table>
<thead>
<tr>
<th>Figure 4 US Tobin q’s*</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>Average</th>
<th>1980-2007</th>
<th>stand dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare</td>
<td>2.36</td>
<td>2.47</td>
<td>2.14</td>
<td>1.69</td>
<td>1.69</td>
<td>0.45</td>
</tr>
<tr>
<td>Technology</td>
<td>1.70</td>
<td>1.64</td>
<td>1.62</td>
<td>1.43</td>
<td>1.43</td>
<td>0.42</td>
</tr>
<tr>
<td>Oil &amp; Gas</td>
<td>1.52</td>
<td>1.44</td>
<td>1.35</td>
<td>1.00</td>
<td>1.00</td>
<td>0.23</td>
</tr>
<tr>
<td>Consumer Services</td>
<td>1.27</td>
<td>1.36</td>
<td>1.23</td>
<td>0.95</td>
<td>0.95</td>
<td>0.18</td>
</tr>
<tr>
<td>Industrials</td>
<td>1.22</td>
<td>1.29</td>
<td>1.26</td>
<td>0.93</td>
<td>0.93</td>
<td>0.16</td>
</tr>
<tr>
<td>Consumer Goods</td>
<td>1.09</td>
<td>1.21</td>
<td>1.10</td>
<td>0.91</td>
<td>0.91</td>
<td>0.13</td>
</tr>
<tr>
<td>Basic Materials</td>
<td>1.41</td>
<td>1.73</td>
<td>1.70</td>
<td>0.90</td>
<td>0.90</td>
<td>0.30</td>
</tr>
<tr>
<td>Telecommunications</td>
<td>1.07</td>
<td>1.29</td>
<td>1.28</td>
<td>0.89</td>
<td>0.89</td>
<td>0.27</td>
</tr>
<tr>
<td>Utilities</td>
<td>0.81</td>
<td>0.90</td>
<td>0.90</td>
<td>0.85</td>
<td>0.85</td>
<td>0.07</td>
</tr>
<tr>
<td>Financials</td>
<td></td>
<td></td>
<td></td>
<td>0.85</td>
<td>0.85</td>
<td>0.26</td>
</tr>
</tbody>
</table>

15 The small effect on profits would then ensure a small effect on GDP and consumption.

16 Even apart from the evidence of Figure 4, anecdotal evidence suggests the returns to capital in farming and housing have traditionally been low.
We set up a 38 industry version of USAGE with the data calibrated so that the implied Tobin q’s are consistent with those in Figure 4. In making the calibration we adjusted the initial USAGE data for capital stocks and gross operating surplus by industry.

4.2 The Effects of Reallocating Capital are Second-order Small

Working with this adjusted database, we used USAGE to compute the effects on economic welfare of:

1. reallocating the U.S. capital stock across industries to equate Tobin qs;
2. reallocating the U.S. capital stock across industries to equate rates of return;

In USAGE, under various simplifying assumptions (Appendix 2), Tobin’s q (TQ_{j,t}) and rates of return ((ROR_{j,t})) for industry j in year t can be represented as:

\[ TQ_{j,t} = \frac{Rent_{j,t} \times (1 - T_t)}{\Pi_{j,t} (RINT_t + D_j)} \]  \hspace{1cm} (3)

\[ ROR_{j,t} = -1 + \frac{\left[(1 - T_t) \times \left(\frac{Rent_{j,t}}{\Pi_{j,t}}\right) \times (1 - D_t)\right]}{(1 + RINT_t)} \]  \hspace{1cm} (4)

where

- \(Rent_{j,t}\) is the gross (before depreciation) profit per unit of capital in industry j in year t;
- \(T_t\) is the rate of tax applying to capital income in year t;
- \(\Pi_{j,t}\) is the cost of constructing a unit of capital in industry j in year t;
- \(RINT_t\) is the safe real interest rate in year t; and
- \(D_j\) is the rate of depreciation on j’s capital.

From (3) and (4) we find that Tobin’s q and rates of return are related by

\[ ROR_{j,t} = \frac{(RINT_t + D_j)}{[1 + RINT_t]} \{TQ_{j,t} - 1\} \]  \hspace{1cm} (5)

Theories of investor behavior suggest that in a long run equilibrium state TQs are one or equivalently RORs are zero. However, as is clear from Figure 4 and from the database of any dynamic CGE model, TQs are often far from 1 for extended periods and similarly RORs are often far from zero. Figure 5 provides an indication of how much welfare is lost by the failure of the economy to operate in its long-run equilibrium state.

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17 Tobin’s q Calculation = (Market Value of Ordinary shares + Book Value of Preference Capital + Total Debt)/Total Assets. Industry Tobin’s q is the Tobin’s q of the median firm within each industry. Financials was deemed to have the average q of utilities, due to a presumption that the finance sector had too many resources in it in 2007, rather than too few. The raw average for financials was 1.21, but the subsequent crisis suggests these shares were seriously overvalued.
Row 8, column 1 of Figure 5 indicates that U.S. welfare, measured by the deviation in consumption (public and private combined), would be 0.0279 per cent higher if capital were reallocated to equalize the TQ$_j$s across all $j$. Column 2 indicates that welfare would be increased by 0.0250 per cent if capital were reallocated to equalize the ROR$_j$s.

The critical assumption underlying these calculations is that the aggregate volume of capital stock in the U.S. is fixed. Coming from a position of non-optimality, this implied that when Tobin’s q was equalized across sectors, it settled at a value different from unity (0.98). Given different depreciation rates across sectors (5) implies that equalizing rates of return is not the same as equalizing the q’s.

Other assumptions are that the reallocation of capital does not affect the trade balance, aggregate employment and net investment. The assumptions explain the zeros in rows 1, 3, 4 and 5 of Figure 5. We choose these assumptions to isolate as much as possible the effects of changing the allocation of capital across industries.

Real GDP falls in both columns 1 and 2 of Figure 5. This is because the reallocation of capital in both simulations is towards industries with low depreciation rates.

As can be seen in Figure 6, in both simulations the ownership of dwellings industry, which has easily the lowest depreciation rate, gains capital. Industries with low depreciation rates tend to have low rentals per dollar’s worth of capital reflecting the limited requirements for gross profits to be used in capital maintenance. Thus, capital in industries with low depreciation rates make relatively low contributions per dollar’s worth of capital to Gross domestic product, but this doesn’t apply to Net domestic product which shows an increase in both simulations (row 7 of Figure 5).
Another indication of the reallocation of capital towards industries with low rentals per dollar’s worth of capital are the negative results in row 2 of Figure 5 for aggregate capital, rental weights. In both simulations the reallocation of capital causes reductions in exports and imports. Detailed checking would reveal that import competing industries have TQs and RORs that are high relative to those of export oriented industries. Consequently, import competing industries gain capital relative to export-oriented industries in the simulations, causing import replacement and export reduction.

**Figure 6. USAGE data and results for the effects of capital reallocations**

<table>
<thead>
<tr>
<th>Industry</th>
<th>USAGE results</th>
<th>USAGE data</th>
<th>Initial values of:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percentage deviations in quantity of capital</td>
<td>Depreciation rates</td>
<td>TQ&lt;sup&gt;(a)&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Equalizing Tobin Qs</td>
<td>Equalizing rates of return</td>
<td></td>
</tr>
<tr>
<td>agric</td>
<td>-0.2163</td>
<td>-0.4732</td>
<td>0.0756</td>
</tr>
<tr>
<td>agrserv</td>
<td>0.3455</td>
<td>0.1298</td>
<td>0.1132</td>
</tr>
<tr>
<td>mining</td>
<td>0.3757</td>
<td>-0.1031</td>
<td>0.0766</td>
</tr>
<tr>
<td>construct</td>
<td>-0.7060</td>
<td>-0.8900</td>
<td>0.1149</td>
</tr>
<tr>
<td>dairySugar</td>
<td>-1.2214</td>
<td>-1.4186</td>
<td>0.0752</td>
</tr>
<tr>
<td>foodmanu</td>
<td>-1.4836</td>
<td>-1.6976</td>
<td>0.0752</td>
</tr>
<tr>
<td>tobaccoProd</td>
<td>-1.9486</td>
<td>-2.1473</td>
<td>0.0693</td>
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<tr>
<td>Apparel</td>
<td>-1.8157</td>
<td>-1.9771</td>
<td>0.0792</td>
</tr>
<tr>
<td>textiles</td>
<td>-2.1786</td>
<td>-2.3789</td>
<td>0.0789</td>
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<tr>
<td>WoodFurn</td>
<td>-1.1272</td>
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<td>PaperPub</td>
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<td>Chemicals</td>
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<tr>
<td>Petrolprods</td>
<td>0.1241</td>
<td>-0.0594</td>
<td>0.0636</td>
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<tr>
<td>Footwear</td>
<td>-2.0757</td>
<td>-2.2249</td>
<td>0.0673</td>
</tr>
<tr>
<td>MetalProds</td>
<td>-1.9353</td>
<td>-2.1108</td>
<td>0.0654</td>
</tr>
<tr>
<td>Machinery</td>
<td>-1.7161</td>
<td>-1.9368</td>
<td>0.0759</td>
</tr>
<tr>
<td>Computers</td>
<td>4.9044</td>
<td>4.6618</td>
<td>0.0759</td>
</tr>
<tr>
<td>ElectMach</td>
<td>8.0567</td>
<td>7.8215</td>
<td>0.0891</td>
</tr>
<tr>
<td>MotorVeh</td>
<td>-1.7221</td>
<td>-1.9767</td>
<td>0.1046</td>
</tr>
<tr>
<td>TransEquip</td>
<td>-1.4573</td>
<td>-1.6344</td>
<td>0.0772</td>
</tr>
<tr>
<td>ManuNEC</td>
<td>-1.1095</td>
<td>-1.3335</td>
<td>0.0917</td>
</tr>
<tr>
<td>Communicat</td>
<td>-2.5492</td>
<td>-2.8047</td>
<td>0.0621</td>
</tr>
<tr>
<td>Utilities</td>
<td>-1.4531</td>
<td>-1.7556</td>
<td>0.0512</td>
</tr>
<tr>
<td>TradMarg</td>
<td>-0.6630</td>
<td>-0.8731</td>
<td>0.0867</td>
</tr>
<tr>
<td>OwnoccDwell</td>
<td>0.7267</td>
<td>0.9091</td>
<td>0.0182</td>
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<td>BusFinServ</td>
<td>-2.2239</td>
<td>-2.3578</td>
<td>0.0984</td>
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<tr>
<td>MedicServ</td>
<td>10.5934</td>
<td>10.4330</td>
<td>0.0736</td>
</tr>
<tr>
<td>Education</td>
<td>-0.6040</td>
<td>-0.6743</td>
<td>0.0416</td>
</tr>
<tr>
<td>SocialServ</td>
<td>-0.7060</td>
<td>-0.8668</td>
<td>0.0823</td>
</tr>
<tr>
<td>Enterprise</td>
<td>-0.0746</td>
<td>0.0412</td>
<td>0.0273</td>
</tr>
<tr>
<td>MiscServ</td>
<td>-0.6870</td>
<td>-0.8570</td>
<td>0.0782</td>
</tr>
<tr>
<td>GovtServ&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>-0.8368</td>
<td>-0.8918</td>
<td>0.0344</td>
</tr>
<tr>
<td>TransMarg</td>
<td>-0.7519</td>
<td>-0.9638</td>
<td>0.0815</td>
</tr>
<tr>
<td>AutoRent</td>
<td>0.1525</td>
<td>-0.0805</td>
<td>0.0700</td>
</tr>
</tbody>
</table>

<sup>(a)</sup> Tobin q’s were allocated to USAGE industries from Figure 4. No information relevant for agriculture or ownership of dwellings was available from Figure 4. For these industries we assumed TQs of one.

<sup>(b)</sup> Industries 33 to 36 have no capital.
With the contractions in trade, the Figure 5 simulations show improvements in the terms of trade (row 12). The improvements in the terms of trade together with the gains in real net domestic product (row 7) combine to explain the welfare gains in row 8.

4.3 Adverse Shocks Have Second-order Small effects

As we saw earlier the envelope theorem suggests that reallocating the capital stock from an optimal allocation will have a vanishingly small effect on economic welfare. The Theory of the Second Best prohibits a corollary that the effect will be larger if there is an adverse shock from a real-world situation where capital is sub-optimally allocated. This must be investigated with a model that recognizes misallocation, like USAGE.

Figure 7. Cost of an Aberrant Shock (%)

<table>
<thead>
<tr>
<th>Increasing q(HealthCare)</th>
<th>off initial database</th>
<th>off database with equalized RORs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>1 aggregate capital,</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>asset wgt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 aggregate capital,</td>
<td>-0.1404</td>
<td>-0.1107</td>
</tr>
<tr>
<td>rental wgt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 aggregate employment</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4 real net investment</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5 balance of trade</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>6 real GDP</td>
<td>-0.0239</td>
<td>-0.0180</td>
</tr>
<tr>
<td>7 real net DP</td>
<td>-0.0193</td>
<td>-0.0064</td>
</tr>
<tr>
<td>8 real consumption</td>
<td>-0.0207</td>
<td>-0.0076</td>
</tr>
<tr>
<td>9 real investment</td>
<td>-0.0356</td>
<td>-0.0637</td>
</tr>
<tr>
<td>10 export volumes</td>
<td>0.0342</td>
<td>0.0318</td>
</tr>
<tr>
<td>11 import volumes</td>
<td>0.0135</td>
<td>0.0125</td>
</tr>
<tr>
<td>12 terms of trade</td>
<td>-0.0114</td>
<td>-0.0106</td>
</tr>
</tbody>
</table>

Figure 7 reports results in which we start from the initial situation (with the q’s from Figure 4 in place) and simulate the effects of an increase of 0.45 (one-standard-deviation) in the q for health care. This is clearly a move in the wrong direction: it increases the inequality among the q’s.

Welfare falls (by 0.0207 per cent, row 8, column 1). In column 2 of Figure 7, we repeat the column-1 experiment but instead of using the initial situation as the starting point, we use the situation arrived at when we equalized rates of return (the Figure 5 simulation). Consistent with the envelope theorem, the increase in health-care q now causes a relatively small loss of welfare (0.0076 per cent compared with 0.0207 per cent).

But both numbers are really quite small. Assuming a discount rate of 5 per cent, the losses should be multiplied by 20 for Net Present Value figures. That is, an aberrant shock from a position of optimality costs NPV 0.15 per cent and an adverse shock from the USAGE allocation is NPV 0.41 per cent of consumption.
The fact that the effect is negative shows that the theory of the second best is practically unimportant (at least for this shock), and, the NPV size suggests that perturbations in the capital stock are historically ‘small’.

5 Conclusion

In this paper, we have argued for the relative unimportance of capital misallocation in USAGE. We have been able to calibrate USAGE with empirical Tobin q’s and proceed with sensible analysis, even though US capital is not optimally allocated. We have established that when capital is allowed to move to equalize returns or Tobin’s q, the benefits are second order small. When a realistic perturbation takes capital away from a capital-starved sector (Healthcare) the NPV effect is both negative and small. This suggests respectively that the theory of second best is unimportant practically, and, that the perturbation in capital associated with historic share market volatility is ‘small’. That is, the intuition of the envelope theorem carries over to a realistic CGE model.

We are therefore relaxed about a degree of asset market interference. We say ‘a degree’ because we are cognizant of the Lucas critique, which we have worked hard to meet in this paper by using a CGE model. Excessive regulation could take misallocation outside the historic range of volatility – away from ‘small’ capital perturbations.

We would be remiss not to mention a number of other obvious caveats.

First, the results naturally depend on the validity of the USAGE model as a descriptor of the US economy. One of the virtues of large scale models is that they force scholars to lay out all their assumptions on the table, warts and all. If other frameworks do not do this, their lack of explicit assumptions should not be mistaken for their absence.

Second, while the gain in welfare from a full reallocation of capital to equate q’s or real returns is small, it does not follow that distortions in an economy might not have large distributional consequences. For example, as a per cent of GDP, the benefits of full trade liberalization are generally small but the global distributional consequences of, say, Europe’s Common Agricultural Policy are by no means trivial.

Having made all these caveats, the overriding message of this paper is that misallocated US capital has fairly small general equilibrium effects. Regulators and policy makers thus have some ‘room to move’ as they explore what we have left unexplored in this paper – the policies and regulatory structures that might limit large swings in asset prices.

\[\text{18 For example, detailed studies of U.S. import restraints (tariffs and quotas) imply that these generate annual welfare losses of no more than a small fraction of one per cent of GDP. See for example USITC (2004 & 2007)}\]
Bibliography
Goodhart (2009), The Regulatory Response to the Financial Crisis, Edward Elgar.
Appendix 1: Description of ‘capital supply’ functions in MONASH handbook

Shock to Tobin’s q
The shock is operationalized through shifts in the investment function in equation/figure (21.1) below. We shock F_EROR_Jj, 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 in the curve shown in Figure 21.1. For a ‘fundamental’ rate of return (EQEROR in 21.1) a negative shock in either variable delivers more investment. 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:

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

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

\[
EROR(j) = 0.114 \times (q(j) - 1)
\]

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

21.1. Capital-supply functions

In MONASH, the capital-supply function for industry j ([f_ in (2.3) and \( \psi_{Kj} \) 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 \[K_{GR} = K_j(j)/K_j(j) - 1\]. 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:

\[
EROR_j = EQEROR_j + DIS_j \tag{21.1}
\]

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.

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:

\[
EQEROR_j = \text{ORN}_j + F_{ERROR}_Jj + F_{ERROR}
+ (1/C_j) \times \left[ \ln(K_{GR} - K_{GR_{MIN}}) - \ln(K_{GR_{MAX}} - K_{GR}) \right]
- \ln \left( \text{TREND}_K - K_{GR_{MIN}} \right) + \ln \left( K_{GR_{MAX}} - \text{TREND}_K \right) \right]. \tag{21.2}
\]

In this equation,

- \( F_{ERROR}_Jj \) is a shock to expectations about industry j and \( F_{ERROR} \) is a shock to expectations generally. To increase Tobin’s q in the paper these errors is lowered. (For a given expected rate of return, this stimulates investment).
- \( K_{GR_{MIN}} \) is the minimum possible rate of growth of capital and is set at the negative of the rate of depreciation in industry j.
- \( \text{TREND}_K \) 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.
- \( K_{GR_{MAX}} \) 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 \( K_{GR_{MAX}} \) as \( \text{TREND}_K \) plus 0.06. Thus, for example, if the historically normal rate of capital growth in an industry is 5%, the maximum feasible rate would be 5.06%.

---

19 This part of 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 (op. cit.) for details, and references.
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 \( \text{TREND}_K(j) \).

**Figure 21.1. The equilibrium expected rate of return schedule for industry \( j \), assuming \( F_{\text{EROR}}_Jj \) and \( F_{\text{EROR}} \) are zero**

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 \( \text{TREND}_K(j) \), 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 \( \text{TREND}_K(j) \), 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[ \frac{\partial \ \text{EQEROR}_j}{\partial \ K_{\text{GR}_j}} \right]_{K_{\text{GR}_j}=\text{TREND}_K(j)} \cdot \left( \frac{K_{\text{GR}_j\text{MAX}_j} - K_{\text{GR}_j\text{MIN}_j}}{(K_{\text{GR}_j\text{MAX}_j} - \text{TREND}_K(j))(\text{TREND}_K(j) - K_{\text{GR}_j\text{MIN}_j})} \right)^{-1} 

\text{ } \tag{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 \( K_{\text{GR}_j} = \text{TREND}_K(j) \).
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\textsuperscript{20}, 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

$$
\left( \frac{\partial \text{EQERO}_j}{\partial K_{GR-j}} \right)_{K_{GR-j} = \text{TREND}_j}^{-1} = \text{SMURF} \quad \text{for all } j \in \text{IND}. \quad (21.4)
$$

### 21.2. Actual and expected rates of return

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

$$
\text{PV}_{j,t} = -\Pi_{j,t} + \left[ Q_{j,t+1}*(1-T_{t+1}) + \Pi_{j,t+1}*(1-D_j) \right]/\left[1 + INT_t*(1-T_{t+1})\right] \quad (21.5)
$$

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
- $\text{INT}_t$ 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 $[\text{INT}_t*(1-T_{t+1})]$. 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\textsuperscript{21} 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

$$
\text{ROR} \_\text{ACT}_j = -1 + \frac{Q_{j,t}*(1-T_{t+1}) + \Pi_{j,t+1}*(1-D_j)}{\Pi_{j,t}*[1 + INT_t*(1-T_{t+1})]} \quad (21.6)
$$

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 ($\Pi_j$) will increase by the current rate of inflation ($\text{INF}_t$). Under these assumptions, their expectation (EROR\_ST$_{j,t}$) of ROR\_ACT$_{j,t}$ is given by

$$
\text{EROR} \_\text{ST}_j = -1 + \frac{Q_{j,t}*(\Pi_{j,t} + (1-D_j))/[1 + \text{R\_INT\_PT\_SE}_t]}{1 + \text{R\_INT\_PT\_SE}_t} \quad (21.7)
$$

where $\text{R\_INT\_PT\_SE}_t$ is the static expectation of the real post-tax interest rate, defined by

$$
1 + \text{R\_INT\_PT\_SE}_t = [1 + \text{INT}_t*(1-T_t)]/[1+\text{INF}_t] \quad (21.8)
$$

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).

$$
\text{EROR}_j = -1 + \frac{(1-T_j)*Q_j + (1-D_j)}{[1 + \text{R\_INT}_t]}, \quad (1)
$$

---

\textsuperscript{20} For example, the Murphy model (Powell and Murphy, 1997) and TRYM (Taplin et al., 1993).

\textsuperscript{21} 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.
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:

\[
q = \frac{Q_{t+1}(1-T)}{\Pi_{t}(1+INT)} + \frac{Q_{t+2}(1-T)(1-D)}{\Pi_{t}(1+INT)(1+INT)} + \frac{Q_{t+3}(1-T)(1-D)^{2}}{\Pi_{t}(1+INT)(1+INT)^{2}} + \ldots \tag{2}
\]

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 \( \Pi \) 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:

\[
q = \frac{(1+INF)Q_{t}(1-T)}{\Pi_{t}(1+INT)} + \frac{(1+INF)Q_{t}(1+INF)(1-T)(1-D)}{\Pi_{t}(1+INT)(1+INT)} + \frac{(1+INF)Q_{t}(1+INF)^{2}(1-T)(1-D)^{2}}{\Pi_{t}(1+INT)(1+INT)^{2}} + \ldots
\]

\[
= \frac{Q_{t}(1-T)}{\Pi_{t}(1+RINT)} + \frac{Q_{t}(1+INF)(1-T)(1-D)}{\Pi_{t}(1+RINT)(1+INT)} + \frac{Q_{t}(1+INF)^{2}(1-T)(1-D)^{2}}{\Pi_{t}(1+RINT)(1+INT)^{2}} + \ldots
\]

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

\[
q = \frac{Q_{t}(1-T)}{\Pi_{t}(1+RINT)} \approx \frac{Q_{t}(1-T)}{[1-1-(RINT+D)]} \approx \frac{Q_{t}(1-T)}{\Pi_{t}(RINT+D)} \tag{3}
\]

Hence, after straightforward manipulation we may connect \( \text{EROR} \) to \( q \).

\[
\text{EROR}_{t} = \frac{(RINT + D)}{[1 + RINT]} \{q - 1\} \tag{4}
\]