Is privatisation good for investment in Australia?

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Abstract

Privatisation was expected to promote investment in the economy as part of improving dynamic efficiency. The relation between aggregate public and private investment in Australia is investigated in an endogeneous ECM framework. Model selection for a simple investment function allows restrictions for neoclassical crowding out or Keynesian crowding in (after Aschauer 1989) in a small open economy. An ECM is estimated including annual aggregate private investment, public investment, income, rate of return, average interest cost, exchange rate and inventories from 1960 to 2005. Public capital appears unresponsive to shocks and crowding out is not evident.

1. Introduction

Privatisation was presented as a policy that would bring about improved investment as part of a strategy to raise dynamic efficiency. This improvement should be manifest in practice in terms of both increased investment and technological improvement. It would be expected that the consequences be observable at the aggregate level, given the assertions that have been made for it. It is the relation between privatisation and investment at the aggregate level that is the focus of this paper. Accordingly this paper investigates aggregate investment relationships in the case of Australia.

If long run growth is to be enhanced, in one view investment might be expected to increase at least in the short run as a consequence of privatisation. This could be regardless of the character of the privatising sector. Privatisation would be seen as the policy solution to underinvestment and rundown capital stock in public infrastructure, utility and other sectors. In this explanation, inevitable inefficiency and rundown in public sector investment is holding back economic growth. Moreover even where public enterprises are efficiently run it may be argued that growth promoting investments are constrained owing to public enterprise objective functions which are not directly commercial profit maximising. In addition the public expenditure required to finance that investment has come to be viewed in policy terms in Australia as inconsistent with balanced or surplus government budgets regarded as requisite for the macroeconomic stability consistent with new growth theory.

The alternative view is that investment could fall after privatisation under various scenarios. Public ownership could have cultivated overinvestment, in which case the efficient outcome at least in the short run would be to lower investment. For instance in the electricity and gas sectors in Australia, one source of public sector inefficiency indicated was that of overinvestment, such as ‘over engineering’. Otherwise an inefficient solution due to market failures and a conflict between attaining short and long run efficiency due to regulatory issues could result in sub optimal investment. Underinvestment has been argued to occur in privatised industries. For instance in the UK gross nonresidential investment as a share of GDP was the lowest in the EU, falling from 18 per cent of GDP in 1979 when the Thatcher government came in, to below 16 per cent in 1989 (with a peak of 20 per cent in 1989) (Florio 2004 pp93-95, citing OECD 1998 p176, p18).

A third view is that privatisation would address what was understood to be an inefficient allocation of public investments implicitly through a substitution for private. In Australia microeconomic reforms of which privatisation was a part were intended to ensure that 'the right investments are made' in that 'benefits at least equal costs', where it was recognised that 'complications' [exist] such as externalities, public goods and the presence of monopolies. [In those areas] 'both public and private suppliers of goods and services may lack the incentive to price outputs and determine investment programs efficiently, that is to seek allocative efficiency' (Forsyth ed 1992 pp6-7). Infrastructure areas of natural monopoly and network externality regulation would replace public ownership in such a way as to bring about improved allocation of resources between current and future production. This was required in industries where pricing for short run efficiency would conflict with resourcing sufficient investment for meeting long run efficiency objectives (King and Maddock 1996 p106). After privatisation increased investment would be required to replace ageing capital stock and bring about improved dynamic efficiency. If privatisation and deregulation or appropriate regulation bring about an improvement in long run efficiency, this ought to be observable in aggregate. A null hypothesis would be that the path of aggregate investment would be no different before and after privatisation, that is investment is privatisation neutral.

This paper sets out to investigate the effects of privatisation on investment in the context of alternative models of investment. These are the neoclassical model in which investment reflects the marginal efficiency of capital, relating the returns to cost of capital, and the accelerator in which investment is adjusting towards a desired level of capital stock as macroeconomic conditions vary. In doing so it considers the determinants of investment in terms of crowding out or crowding in. It is recognised that the role of public investment may be endogenous to postulated investment models and this is investigated. The focus is on identifying long run relationships and the role of privatisation in their determination. Use is made of information from aggregate time series data for the case of a small open economy that is Australia. The paper sets out the model for estimation and the methodology utilised for testing the model. It discusses the estimation results and the findings.

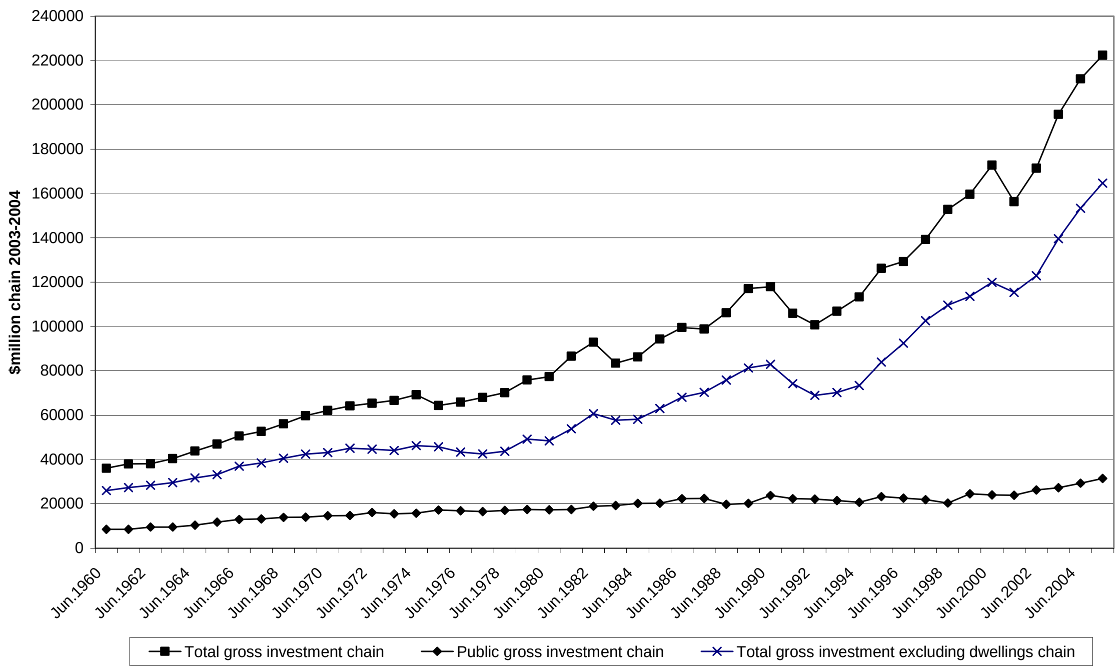
The following section examines the dimensions of public and private investment in Australia.

2. The dimensions of public and private investment

An impression of the magnitude of the privatising process and its importance in aggregate and to various Australian industry sectors can be gained from this section. The following charts show public and private investment in Australia in total and industry sectors for the period 1960 to 2005. The data source is the Australian Bureau of Statistics (ABS). Annual series are used as the focus is on medium to long run relationships and the ABS has indicated that these annual data are more reliable than the more frequent data. Chain index series were not available for public and private investment by industry. The following charts present derived 'quasi chain' index series for public and private investment. These were obtained by taking the current measures of public (including both public corporations and general government at all levels of government) and private investment as proportions of the chain figure for each year. They are quasi as in general chain magnitudes are not additive. However the assumption is made here that the price deflators for private and public investment in each industry sector are not much different.

Chart 1 shows the aggregate gross public investment series at the bottom, adding on the series for private gross investment excluding investment in housing, and then including it to make up the series' total shown by the top line. While public investment increases very slowly and steadily, private investment grows much more rapidly and variably. The strong upward movement and cyclicality in private investment relative to public is notable particularly in later years. The large contribution of dwellings to total investment is also shown.

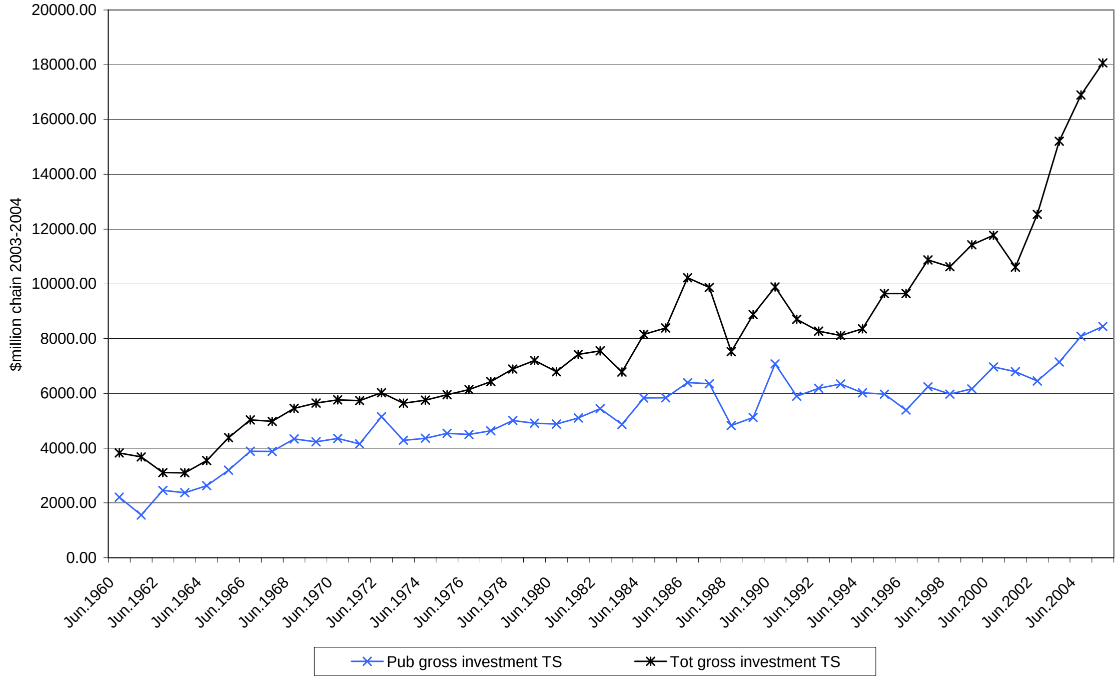
Chart 1 Total economy, public and private gross investment 1960-2005



Source: Derived from ABS spreadsheet tables 520401, 5204064, 5204065, 5204066 and 5204071

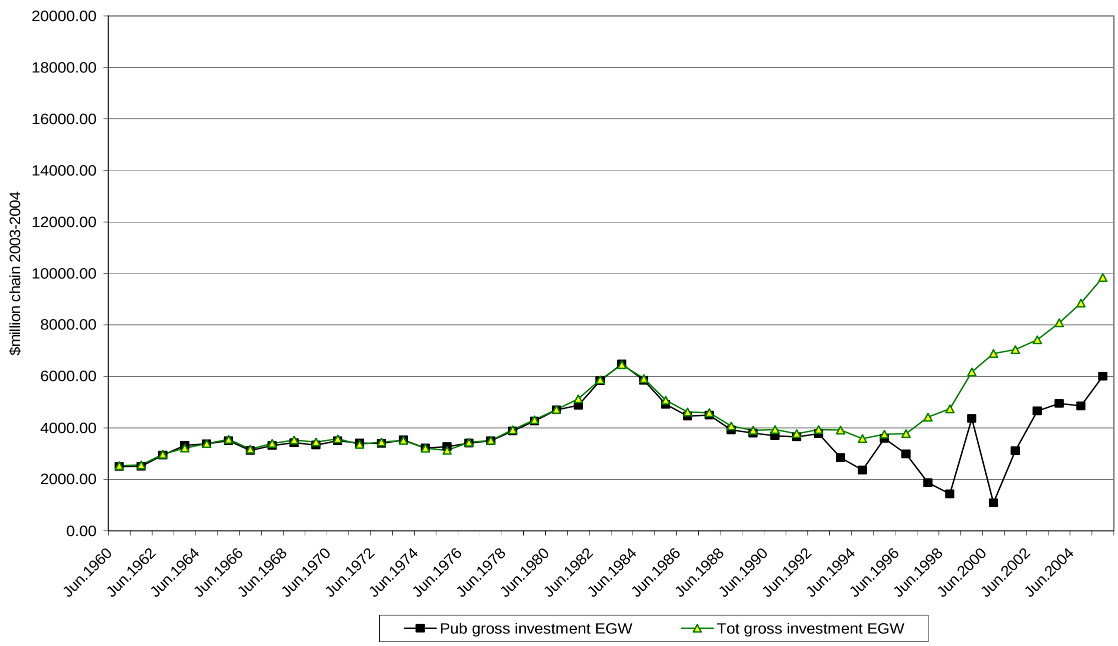
It is worth considering the transformation of ownership at industry level that underlies the aggregate data shown in Chart 1. The movements in investment at industry level (ANZSIC division) underlying the aggegate data are shown in the following charts, beginning with the more privatising industries. The vertical scale intervals of A$20000 million chain index in Chart 1 are in the magnitude of each of the larger industry sectors involved with public investment. These are transport and storage in Chart 2, electricity gas and water in Chart 3, communications services in Chart 4, and finance and insurance in Chart 5 which are all shown on the same scale for comparison. These are followed by charts showing investment in the smaller sectors which include public investment. The scale for these charts is A$6000 million chain. Chart 6 shows education, Chart 7 health and community services and Chart 8 cultural and recreational services. These are followed by charts for the larger essentially private investment sectors shown on the same scale of A$20000 million chain as the previous large sectors. These are Chart 9 for property and business services, Chart 10 for mining, Chart 11 for manufacturing and Chart 12 for agriculture fisheries and forestry. Chart 13 shows gross investment in the remaining small industry sectors which include minimal or no public investment: construction, wholesale and retail trade, accommodation cafes and restaurants, and personal and other services, on the same scale as the previous small sector charts.

Chart 2 Transport and storage public and private gross investment, 1960-2005



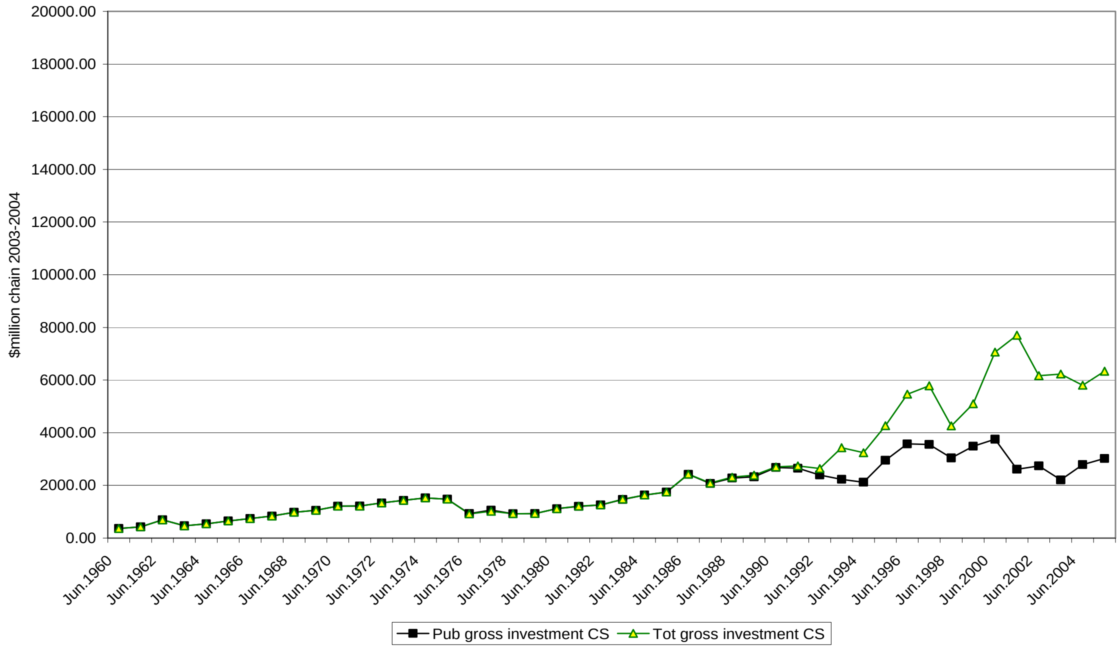
Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 3 Electricity gas and water public and private gross investment, 1960-2005



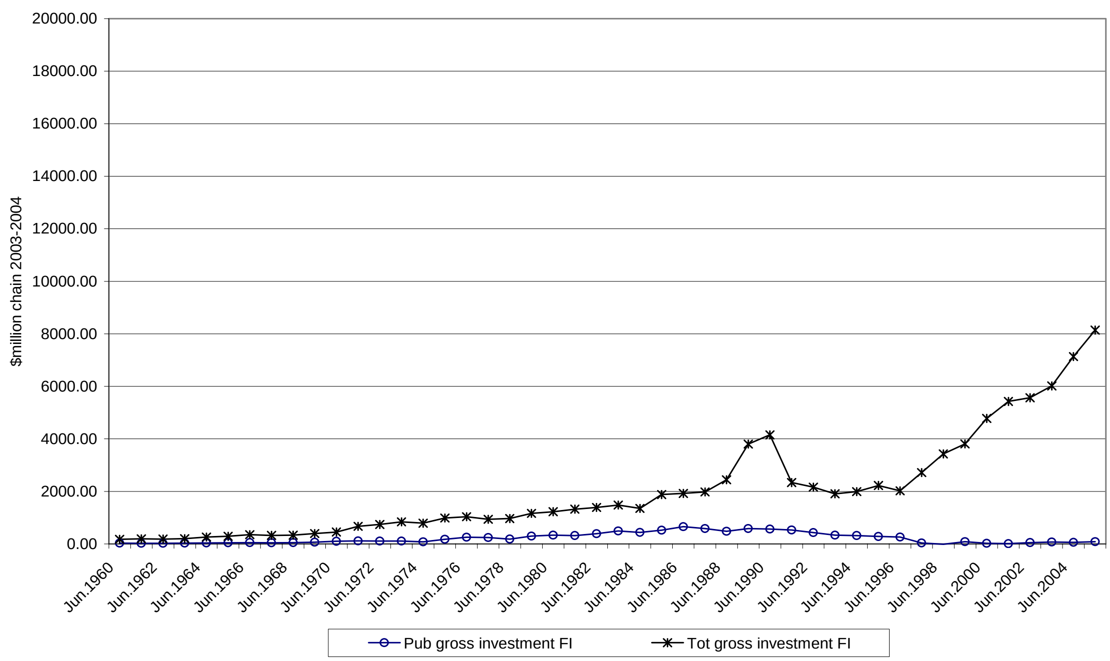
Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 4 Communications services public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

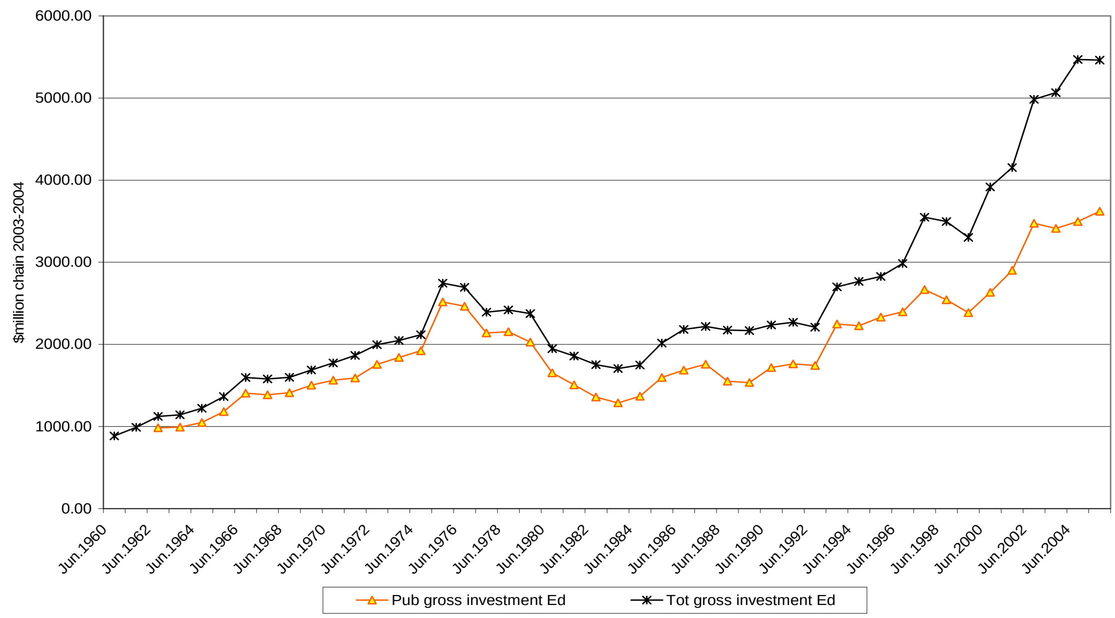
Chart 5 Finance and insurance public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

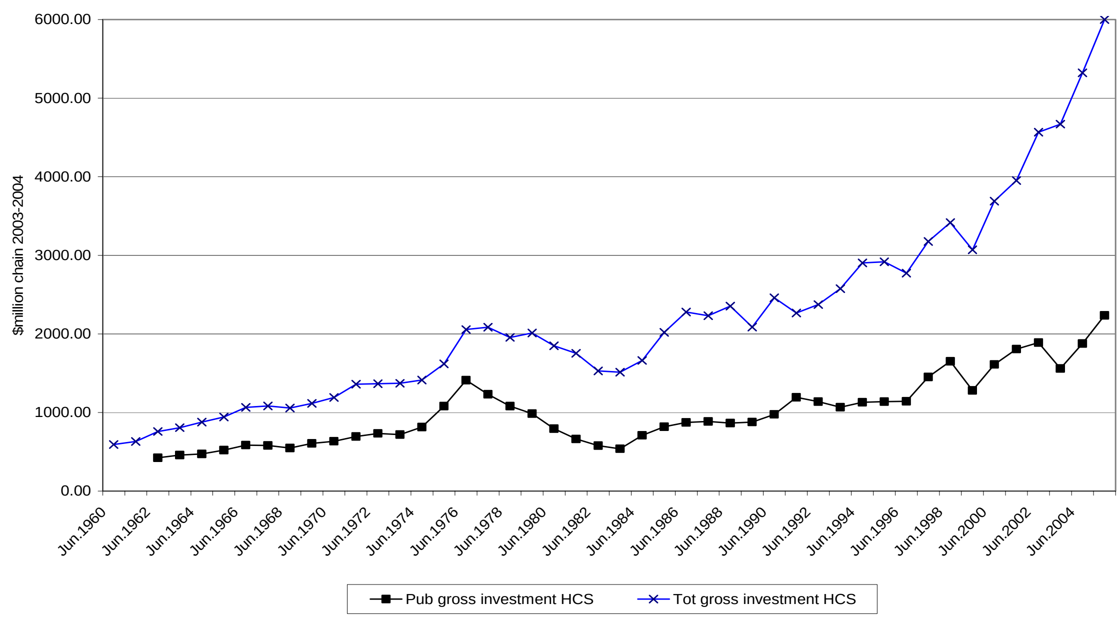
The following charts show the smaller sectors with significant public investment.

Chart 6 Education public and private gross investment, 1960-2005



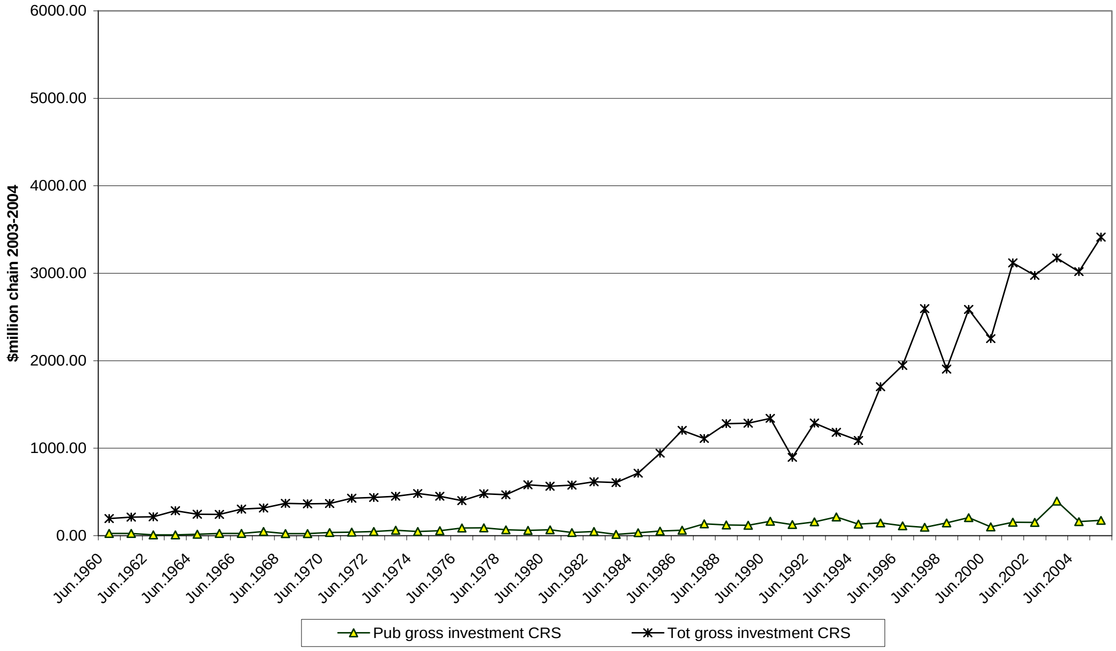
Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 7 Health and community services public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

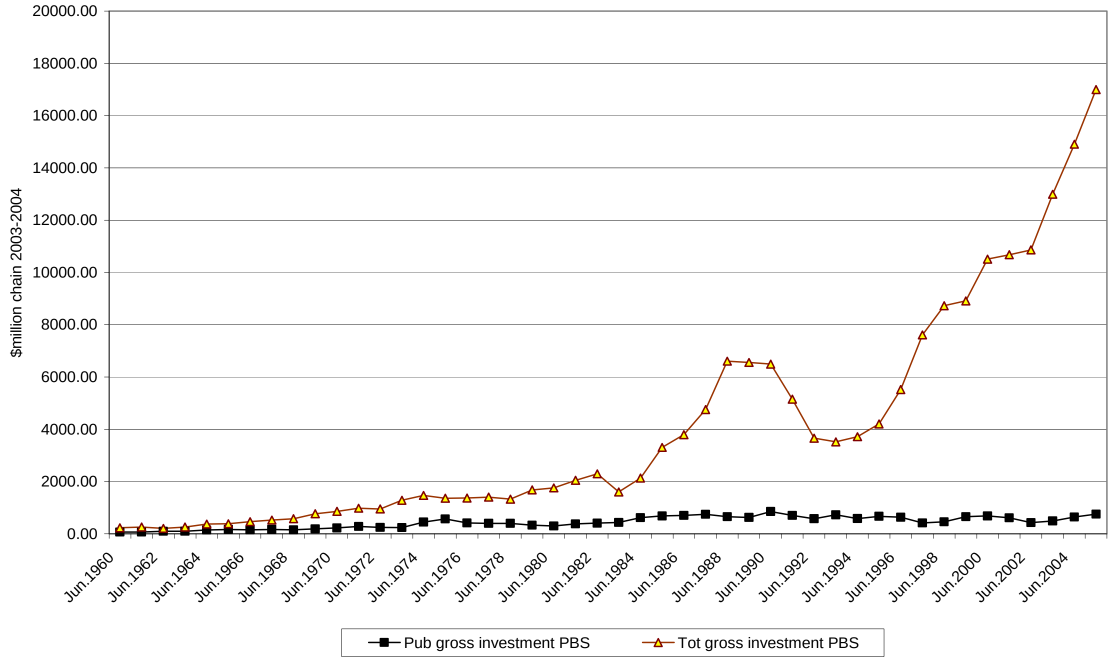
Chart 8 Cultural and recreational public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

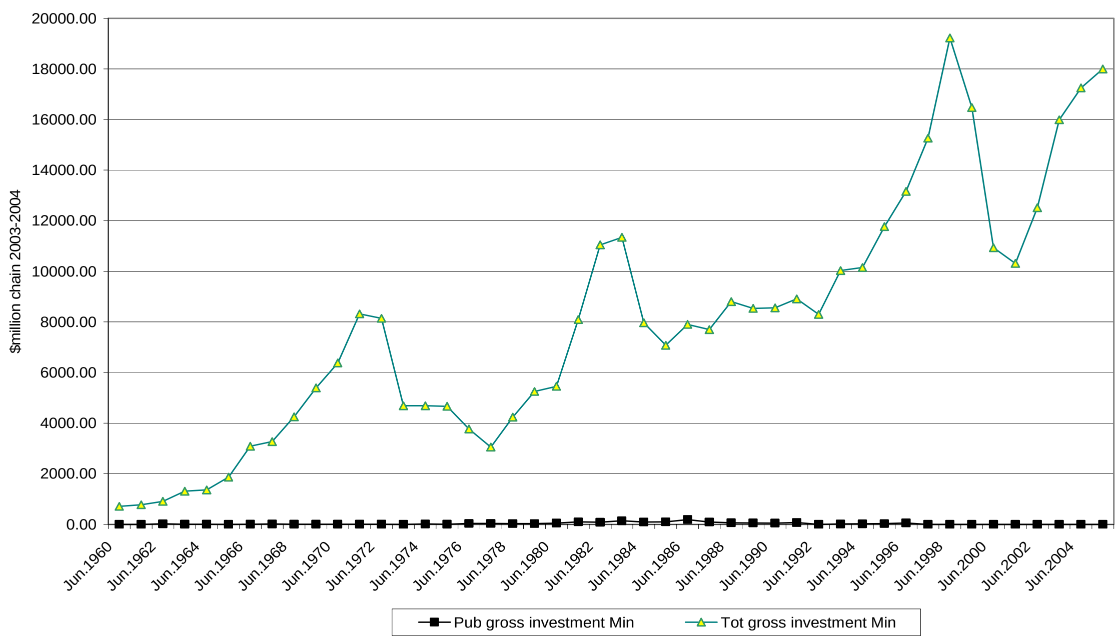
Chart 9, Chart 10, Chart 11 and Chart 12 show gross investment in the larger more or less private industry sectors using th same scale as Chart 2, Chart 3, Chart 4 and Chart 5 above for comparison. Chart 9 shows that gross investment in the property and business services sector has grown particularly steeply. The increase apparently coincides with the increase in IT investment. It is worth noting that this sector includes units engaged predominantly in renting and leasing assets as well as a wide range of business services including architectural and surveying, legal and accounting, data processing and office, advertising, management consultancy, market research, and credit assessing and reporting. It also includes pest control, cleaning, caretaking, protection and contract packing. While this sector is characterised as private, it includes an ongoing small proportion of public investment.

Chart 9 Property and business services public and private gross investment, 1960-2005



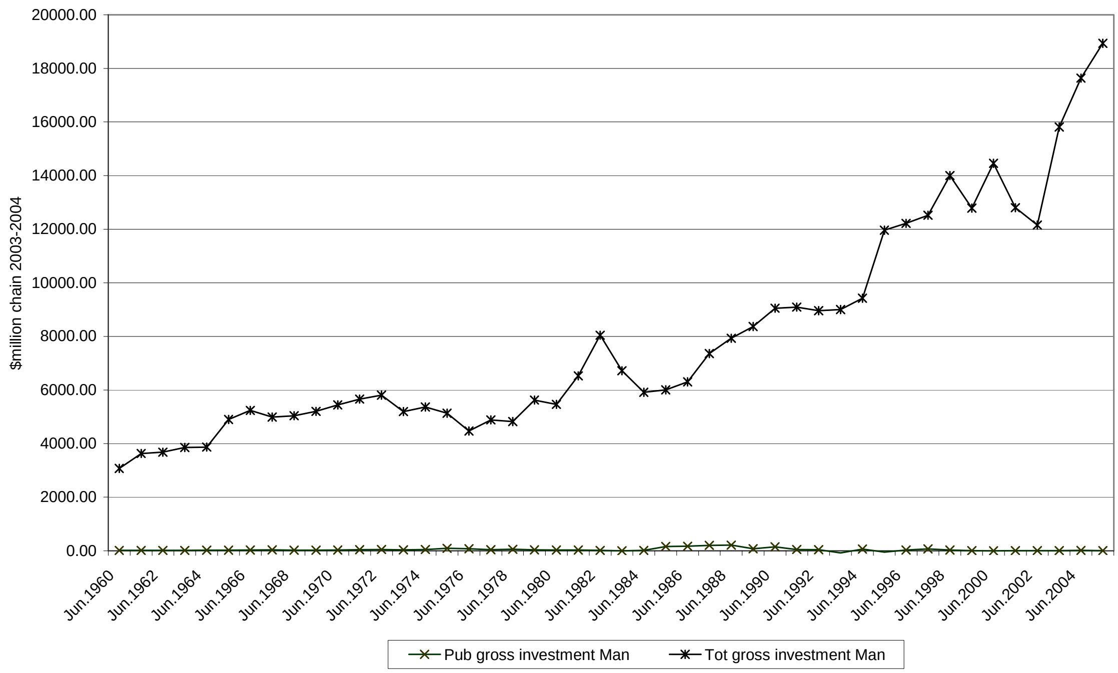
Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 10 Mining public and private gross investment, 1960-2005



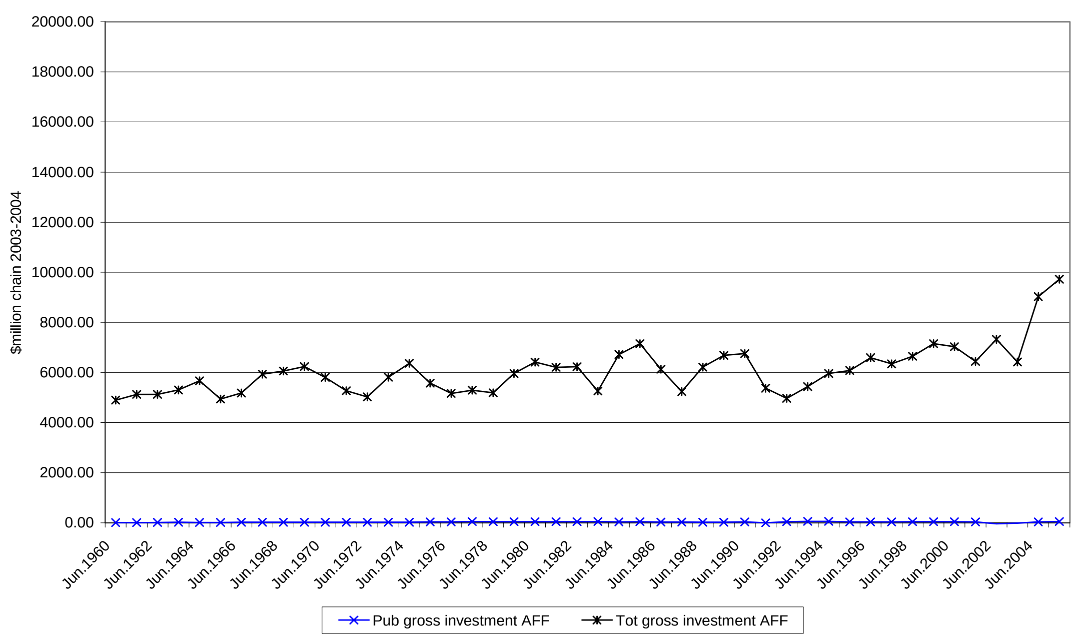
Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 11 Manufacturing public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

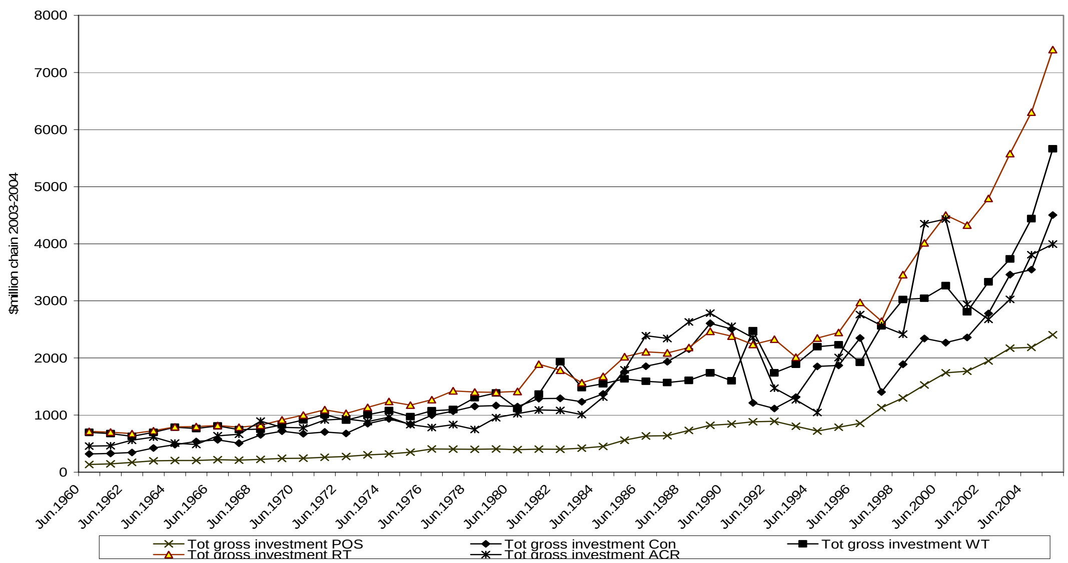
Chart 12 Agriculture fisheries and forestry public and private gross investment, 1960-2005



Source: Derived from ABS spreadsheet tables as for Chart 1

Chart 13 shows gross investment in the remaining small industry sectors which include minimal or no public investment. The sectors are construction, wholesale and retail trade, accommodation cafes and restaurants, and personal and other services. Note the different scale which is similar to that of the previous charts for the smaller sectors which included public investment.

Chart 13 Small industry private sector gross investment, 1960-2005



Source: ABS spreadsheet tables as for Chart 1

3. Models of investment

This question has been examined in an increasing literature for various countries and levels of aggregation. A commonly used approach is to examine the model of Aschauer (1989) which incorporates a positive externality running from public infrastructure to private capital. This is investigated using a cointegration vector autoregregression (VAR) with various degrees of structural and dynamic restriction such as an error correction mechanism (ECM). Studies for Australia remain limited. Monadjemi and Huh (1998) investigates the relation between aggregate private and government investment in Australia, Britain and the US, in a model which included quarterly real variables for private investment, corporate profit, the interest rate and real government investment. From cointegration tests for ordering a VAR in an ECM model it was found that corporate profit and the interest rate were the variables most affecting private investment, with public investment shocks having no effect except in Australia where they crowded out private investment (Monadjemi and Huh 1998 pp100, 102).

The relation between public and private investment has been examined at the aggregate level for the US and Canada (Voss 2002). It used a VAR based on Jorgenson's model of investment to incorporate some dynamics into the model which is widely used to investigate a positive externality arising from public infrastructure (Aschauer 1989). A reduced form restricted VAR was estimated for quarterly data over four decades for real GDP, the relative prices of private and public sector investment goods, the real interest rate and the shares of public and private sector investment in output. The restricted VAR was ordered assuming public investment was exogenous in particular of private investment. The reduced form residuals were orthogonalised so that the dynamic effects of exogenous shocks to particular innovations could be analysed (Voss 2002 p645). It was found that public investment crowded out private investment in both countries. The accelerator effect appeared to be more important for the US than Canada whereas the real interest rate appeared to be more important for Canada, and a negative public investment accelerator was found for both (Voss 2002 p662).

Rossiter (2002) makes use of a structural cointegration analysis order to investigate the Aschauer relation between public and private investment quarterly data disaggregated into equipment and structures for the US, drawing on Pesaran and Smith (1998). With limited degrees of freedom available for testing models with long run properties this allows some sensible a priori restrictions to be imposed. These trade off structural model properties against dynamic properties in terms of information. This approach 'encourages links between the new literature of cointegrating vector autoregressions and the more traditional literature of dynamic structural econometric modelling' (Rossiter 2002 p59). It was found that public investment in equipment crowded out whereas public investment in structures weakly crowded in private investment in the US.

This paper investigates the relation between public and private investment in the case of the Australian economy over the period June 1960 to June 2005. The question as to how privatisation has affected the rate of investment is examined through investigating the role of public and private investment at the aggregate level. This is intended as a study prior to further investigation at the industry level. Aggregate investment is modelled in an investment function which includes typical arguments from which both classical productivity and Keynesian expectations can be tested. This allows testing of alternative behavioural models of investment in terms of crowding out and crowding in.

One difference is in the use of annual data series which updates previous findings based on quarterly data. Aggregate data of annual frequency are used on the basis that they represent the sum of investment decisions and processes undertaken by firms according to the financial year. The use of annual data reflects the long lead times and slow processes of adjustment that characterise investment. The approach also has the virtue of recognising that the annual data are more accurate as according to the Australian Bureau of Statistics (ABS). It is understood that a great deal of interpolation is undertaken in order to obtain quarterly investment and stock series. The approach taken in this paper appeals to understood structural relations in the context of limited information for the application of a restricted VAR given the sample size. The causalities are investigated in a cointegration framework which limits the dynamics. This is done through using a simple accelerator specification which allows both neoclassical and Keynesian assumptions in modelling investment. In a reduced form, the classical investment function includes the interest rate and the Keynesian accelerator includes lagged output. This allows testing for crowding out or crowding in respectively. One departure is that the open aspects which might be important to investment decisions in this mostly small open economy are captured through inclusion of a trade weighted index. This paper takes the view that this approach achieves a net gain in findings with regard to the long run. The period over which most privatisation has occurred is now more than two decades. This should be adequate to analyse structural change.

Ideally this would be done in a manner which enabled full testing for both functional form and dynamics. However with the limited degrees of freedom which are available for testing models with long run properties then some sensible a priori restrictions must be imposed. These trade off structural model properties against dynamic properties in terms of information. In order to do this use is made of a structural cointegration analysis based on Rossiter (2002) drawing on Pesaran and Smith (1998) as set out below. Accordingly economic theory is appealed to in order to identify the cointegration vectors. Here this is investment model arguments incorporating the role of public and private investment as crowding in or out. The structural cointegration approach also enables incorporation of a treatment of the stationarity of variables. Model selection criteria and diagnostic tests are made use of to specify short run dynamics, deterministic components and cointegration rank. It enables some interpretation of convergence processes.

A simple error correction model (ECM) is used to investigate initially aggregate investment in a model which includes elements of the traditional accelerator of Eisner and Strotz (1963) and the neoclassical marginal efficiency of capital. The accelerator version would include sensitivity of investment to change in output as a proxy for capital stock adjustment for growth as well as to cyclical factors reflected in capacity utilisation captured by inventory changes. It includes a profitability or cash flow variable (Rossiter 2002 p60). It includes the rate of interest which at the annual data frequency is understood as a blunt proxy for variation in the average cost of capital across financial years. Public investment is added to these typical variables for the purpose of this paper. For crowding out, public investment is allocatively or X inefficient or leads to private firms in sector to revise downwards their investment plans to re adjust to the optimal level of capital stock. Alternatively for crowding in, the positive externality from public investment in the sector raises sectoral returns and output growth.

This is modified in this paper as some variables are assumed to be exogenous in this model of aggregate investment, and additional restrictions are placed on the lag operator in the VAR for use of annual data. Use is also made of the information about stationarity of time series and cointegrating relationships.

4. Model for estimation

The model used for for the purposes of investigation in this paper is a restricted version of the general autoregressive (VAR) model

$$Y_t = A(L)\, Y_t + V_t$$

(Equation 1)

Where Y_t is a vector of aggregate time series variables and A (L) is a p x p polynomial matrix in the lag operator L, and V_t is a vector of random disturbances distributed $V_t \sim N(0, \Sigma)$ (Monadjemi and Huh 1998 p96).

The general version is restricted in recognition of structural and dynamic features of the specification which appeal to economic theory and for convenience in taking advantage of some properties in estimation of an ECM in a small sample size.

This is taken from Rossiter (2002 p63) as:

$$\Delta y_t = a_{0y} + a_{1y}t - \Pi_y z_{t-1} + \sum_{i=0}^{p-1} \Gamma_{iy}\, \Delta z_{t-i} + \Psi_y w_t + \varepsilon_t , \qquad t = 1,2, \ , n,$$

(Equation 2)

'where y_t is a (m_y x 1) vector of endogenous I(1) variables, x_t is a (m_x x 1) vector of I(1) exogenous variables, $z_t = (y_t' , x_t')'$, w_t is a (q x 1) vector of exogenous I(0) variables excluding intercepts and trends, and t is a time trend. Δ is the difference operator and a_{0y}, Π_y etc. are coefficients. The model assumes feedback from Δy to Δx but not feedback in levels so that x_t can be given as'..

$$\Delta x_t = a_{0x} + \sum_{i=1}^{p-1} \Gamma_{xi}\, \Delta z_{t-i} + \Psi_x w_t + v_t ,$$

(Equation 3)

..'and the disturbances ε_t and v_t .. ..are are distributed independently of w_t ' (Rossiter 2002 p63).

For this paper $m_y = 1$ and $p = 1$ are imposed *a priori* on the model in (Equation 1) in an ECM which acknowledges structural restrictions and the limited degrees of freedom available.

The ECM allows modelling of long run relations between variables on an adjustment path from short run dynamics. This has the added virtue of addressing the problem of nonstationary series in levels estimates by making use of differenced data which if I(1) makes for estimation of cointegrating equations. However if this is the case the difficulty of obtaining long run estimates remains. Fortunately Error Correction Models (ECMs) provide a way to do this (Dowrick 2000). ECMs allow incorporation of differences and lagged levels terms in the one specification to reflect equilibrium responses at each period plus a disequilibrium response rate at which variables including the dependent variable adjust to their long run relations. Provided the sign on the lagged dependent variable is negative, the equation is cointegrated. This will hold as long as the model is not mis specified as indicated by serially correlated errors. The ECM also nests various restrictions reflecting alternative models of investment behaviour including crowding out and crowding in.

In the first stage the restricted ECM which adds Δx_t to (Equation 2) is estimated as a reduced form

$$\Delta \ln IP_t = \beta_0 + \beta_1 T + \beta_2 \Delta \ln IG_t + \beta_3 \Delta \ln Q_t + \beta_4 \Delta \ln PRFR_t + \beta_5 \Delta \ln R_t + \beta_6 \Delta \ln TW_t$$

$$+ \beta_7 [\alpha_1 \ln IG_{t-1} + \alpha_2 \ln Q_{t-1} + \alpha_3 \ln PRFR_{t-1} + \alpha_4 \ln R_{t-1} + \alpha_5 \ln TW_{t-1} - \ln IP_{t-1}]$$

$$+ \beta_8 \ln INVN_t + \beta_9 DP_t + \varepsilon_t$$

(Equation 4)

where ln is the log of the variable

- Δ is the first difference of the variable,
- IG_t is public investment in year t,
- IP_t is private investment in year t,
- Q_t is total income in year t,
- $PRFR_t$ is the profit rate (profit/capital stock) in year t,
- R_t is the interest rate in year t
- TW_t is a trade weighted index in year t and
- $INVN_t$ is inventories in year t.
- DP_t is a dummy = 0, t = 1, … , 21, and = 1, t=22 , … , 46
- ε_t is ln u_t , error term, assumed to be log normal.

The general model expressed in a reduced form for estimation is taken to include a single (m_y = 1) I(1) endogenous variable (IP_t), a vector (m_x = 5) of I(1) exogenous variables (IG_t, Q_t, $PRFR_t$,R_t, TW_t), a single (q=1) exogenous I(0) variable ($INVN_t$), and a dummy variable which distinguishes the pre privatisation and privatisation periods. β_7 is the coefficient of adjustment, measuring the extent to which private investment adjusts from the previous period. A negative sign on this indicates the tendency of the system to converge to a stable long run value and relationships which cointegrate. The coefficients $\alpha_1, \alpha_2, \ldots, \alpha_n$, are interpreted as giving long run parameter values where cointegrating values between the variables reflect the structural model.

However in addition to the lagged endogenous variable IP_t, endogeneity also is possible through IG_t in the reduced form estimation. Accordingly the potential for simultaneous equations bias is investigated in terms of possible endogeneity which could arise through the influence of the other RHS variables on IG_t. If this is present then the estimates obtained from (Equation 4) would be biased.

The simultaneity is expressed through nonzero covariance of the error terms in the system

$$\ln\Delta IP_t = \beta'_1 \ln x_t + \varepsilon_{1t}, \qquad \text{(Equation 5)}$$

$$\ln\Delta IG_t = \beta'_2 \ln x_t + \varepsilon_{2t}, \qquad \text{(Equation 6)}$$

where β'_1 and β'_2 are vectors of coefficients on the exogenous variables included in (Equation 4) including differences and lags (ie excluding IP_t and IG_t) in log terms, given as $\ln x_t$ in (Equation 5) and (Equation 6) respectively, and ε_{1t} and ε_{2t} are the respective error terms. The variance covariance matrix of errors for the system is given as

$$\begin{bmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{12} & \sigma_{22} \end{bmatrix}$$

Then (Equation 4) is expressed as

$$\ln\Delta IP_t = \delta_1 \Delta\ln IG_t + \delta_2 \ln x_t + \nu_t, \qquad \text{(Equation 7)}$$

where $\delta_1 = \sigma_{12} / \sigma_{22}$, and the vector $\delta_2 = \beta'_1 - (\sigma_{12} / \sigma_{22}) \beta'_2$ give unbiased estimates of coefficients, and $\nu_t = \varepsilon_{1t} - E(\varepsilon_{1t} \mid \varepsilon_{2t})$.

The unbiased estimates are thereby obtained through estimating (Equation 5) and (Equation 6) and computing the coefficients as adjusted for the the variances and covariances of the respective error terms. The coefficients estimated directly from (Equation 4) are then compared with those obtained from (Equation 5) and (Equation 6) for bias. Long run elasticities calculated from these can also be compared.

5. Methodology

The methodology has the following stages

1. An investigation of the stationarity properties of the variables.
2. Estimation by OLS of the general reduced form ECM model in logs including all hypothesized structural variables. A model selection search down is undertaken by testing of

restrictions on regression coefficients including intercept and slope dummies for structural change, in order to obtain a preferred specification.

3. An investigation of endogeneity in public investment IG_t from the general model and the preferred specification as obtained from the model search.
4. A comparison of elasticities obtained from the reduced form versions and the unbiased estimates.

1. The standard investigation of the stationarity properties of the variables was undertaken in order to determine the order of integration of the raw data series. This was done using ADF tests in Eviews and allowing the lag length for uncorrelated errors to be obtained from the standard search up to 9 lags by Schwartz Information Criterion (SIC). If variables are found to be I(1), it is maintained that this would allow an error correction mechanism (ECM) to be estimated which includes levels in the specification. If the specification is found to be cointegrating, it can be argued that the relationship amongst the variables is a valid one. Cointegration is indicated by the correct (negative) sign on the lagged endogenous variable and an absence of serial correlation in the residual, as obtained by the Breusch Godfrey LM test on the residual where the null is no serial correlation in the residuals, which is distributed as an asymptotic χ^2.

2. A model selection test was undertaken by testing down from the general (Equation 4) to restricted specifications in a Hendry style approach. This is done in the first instance by log likelihood ratio test (LLR) of OLS estimates from restricted versions omitting variables with insignificant coefficients against a version in which they are included. This is

$$LLR = -2(LL_R - LL_U) \sim \chi^2_{,k}$$

Where LLR is Log Likelihood Ratio, LL_R is the log likelihood of the restricted version and LL_U is the log likelihood of the unrestricted version, distributed χ^2 with degrees of freedom = k, where k is the number of restrictions imposed. This is tested where
H_0 = restricted version and H_A = unrestricted version. It is recognised that the test is asymptotic and somewhat weak in samples of this size. Other criteria such as inspection of the standard errors are also applied.

3. Possible bias in the estimates from (Equation 4) was investigated by estimating (Equation 5) and (Equation 6) by OLS and deriving the unbiased estimates as described above.

4. Elasticities directly estimated as the coefficients in the log versions were compared with the unbiased estimates. The stability of derived long run elasticity estimates was investigated by Wald test.

6. Data for Australia

Data was obtained from the Australian Bureau of Statistics (ABS) and the Reserve Bank of Australia (See Appendix 1). All are annual series from June 1960 to June 2005 expressed in volume terms chain index 2003-2004 except the interest rate R_t . IP_t is private investment excluding dwellings which are treated here as consumption. IG_t is aggregate public investment excluding the very small dwellings component. Q_t is gross domestic income, $PRFR_t$ is the profit rate (profit/capital stock) where profits are gross operating surplus and capital stock is total net capital stock. R_t is the annual average nominal interest rate obtained from the monthly government cash or short term bond rate. TW_t is a trade weighted index intended to reflect movements in the terms of trade over time and $INVN_t$ is inventories included in order to capture cyclical effects.

7. Hypothesis testing and results

1. Tests for stationarity of the time series variables (Table 4).

As is typical of aggregate time series it was found that the null of a unit root could not be rejected for most variables in levels from ADF tests (Table 4). However most of these were found to be I(1) as the null of a unit root was rejected at the 5 per cent level of the t test (at least) for first and second differences. The exception was $INVN_t$ inventories where the null was also rejected in the tests of levels and is I(0), and KT_t and W_t where the null was not rejected for first differences. Accordingly use is made of these results for estimation of an ECM the results of which will be valid for the cointegrating relationship. Breusch-Godfrey tests for serial correlation of the residuals found the null of no serial correlation of the residuals not to be rejected at the 5 per cent level of the asymptotic χ^2 test throughout the estimations. The properties at this size of sample of course remain an issue.

2. OLS estimation of specifications in logs for the purpose of testing down of restrictions (Table 5 and Table 6).

The general specification (Equation 4) above including the dummy variable was found preferred to the restricted version $\beta_9 = 0$. Accordingly (Equation 4) is the starting point for the model selection, as given in the first two rows of Table 5. The OLS regression yields

$$\Delta lnIP_t = \underset{(2.14)}{11.0} + \underset{(3.80)}{0.06T} + \underset{(0.19)}{0.04\Delta lnIG_t} + \underset{(4.59)}{4.93\Delta lnQ_t} + \underset{(2.34)}{-1.61\Delta lnPRFR_t} + \underset{(0.57)}{0.04\Delta lnR_t} +$$

$$\underset{(1.45)}{-0.39\Delta lnTW_t} + \underset{(1.48)}{0.35lnIG_{t-1}} + \underset{(1.99)}{-0.97lnQ_{t-1}} + \underset{(2.34)}{0.83lnPRFR_{t-1}} + \underset{(2.82)}{0.13lnR_{t-1}}$$

$$\underset{(1.03)}{-0.24lnTW_{t-1}} - \underset{(4.43)}{(-0.50)lnIP_{t-1}} + \underset{(0.0)}{-0\ lnINVN_t} + \underset{(2.43)}{-0.16\ DP_t} + 0.0722 \quad \text{(Equation 4)}$$

There is no established approach to the order for testing down, and a number of orderings were investigated. The model selection process was tailored to take into account the limited degrees of freedom. It also sought to investigate the hypothesis of different behaviour in the periods 1960 to 1984 and 1985 to 2005. The direction of the search was also based on a priori structural information regarding investment functions. The need to investigate a possible structural break was indicated from the outset by the support from hypothesis testing for the preferred general specification including an intercept dummy split for the a priori pre privatisation 1960 to 1984 and the privatising period 1985 to 2005. H_0 was the restricted version and H_A the unrestricted version. The key findings from the testing down of restrictions sequentially on (Equation 4) were

1. H_0: $\beta_9 = 0$, H_A : $\beta_9 \neq 0$, H_0 rejected, include DP_t in regression
2. H_0: $\beta_8 = 0$, H_A : $\beta_8 \neq 0$, H_0 not rejected, drop $INVN_t$ from regression
3. H_0: $\alpha_5 = \beta_6 = 0$, H_A : $\beta_6 \neq 0$, $\alpha_5 \neq 0$, H_0 not rejected, drop TW_t variables from regression
4. H_0: $\alpha_4 = \beta_5 = 0$, H_A : $\alpha_4 \neq 0, \beta_5 \neq 0$, H_0 rejected, include R_t variables in regression
5. H_0: $\alpha_3 = \beta_4 = 0$, H_A : $\alpha_3 \neq 0, \beta_4 \neq 0$, H_0 rejected, include $PRFR_t$ variables in regression.
6. H_0: $\alpha_2 = \beta_3 = 0$, H_A : $\alpha_2 \neq 0, \beta_3 \neq 0$, H_0 rejected, include Q_t variables in regression.
7. H_0 : $\alpha_1 = 0$, H_A : $\alpha_1 \neq 0$, H_0 not rejected, drop IG_t variables from regression.

Further hypothesis testing supported deleting the inventory variable and the variables related to the trade weighted index. Deleting the lagged levels variables was not supported. The inclusion of slope dummies was not supported.

The results after step 6. above found specification 3 (last two rows in Table 5) not to be rejected, as reported in Table 6. The OLS regression yields

$$\Delta lnIP_t = \underset{(2.87)}{12.7} + \underset{(4.64)}{0.06}T + \underset{(0.03)}{0.01}\Delta lnIG_t + \underset{(4.54)}{4.47}\Delta lnQ_t + \underset{(3.22)}{-1.71}\Delta lnPRFR_t + \underset{(0.57)}{0.04}\Delta lnR_t +$$

$$+ \underset{(1.29)}{0.30}lnIG_{t-1} + \underset{(2.66)}{-1.14}lnQ_{t-1} + \underset{(2.15)}{0.66}lnPRFR_{t-1} + \underset{(2.90)}{0.13}lnR_{t-1}$$

$$- \underset{(4.43)}{(-0.47)}lnIP_{t-1} + \underset{(2.33)}{-0.14}DP_t + 0.0717$$

(Equation 8)

If the model at step 7. is taken to be the preferred one as shown in the last two rows of Table 6, this is

$$\Delta lnIP_t = \beta_0 + \beta_1 T + \beta_3\Delta lnQ_t + \beta_4\Delta lnPRFR_t + \beta_5\Delta lnR_t + \beta_7[\alpha_2 lnQ_{t-1} +$$

$$+ \alpha_3 lnPRFR_{t-1} + \alpha_4 lnR_{t-1} - lnIP_{t-1}] + \beta_9 DP_t + \varepsilon_t$$

(Equation 9)

The regression results from (Equation 9) are

$$\Delta lnIP_t = \underset{(2.64)}{11.4} + \underset{(4.51)}{0.06}T + \underset{(4.64)}{4.49}\Delta lnQ_t + \underset{(3.20)}{-1.67}\Delta lnPRFR_t + \underset{(0.53)}{0.03}\Delta lnR_t +$$

$$+ \underset{(2.32)}{-0.77}lnQ_{t-1} + \underset{(1.72)}{0.48}lnPRFR_{t-1} + \underset{(2.90}{0.12}lnR_{t-1}) - \underset{(4.6)}{(-0.44)}lnIP_{t-1} + \underset{(1.9)}{-0.11}DP_t + 0.18$$

(Equation 9)

3. Investigation of possible bias in the estimates of (Equation 4) and further reduced form specifications was undertaken through estimation of (Equation 5) and (Equation 6) as described above.

The results from the reduced form and unbiased estimates are shown in Table 1 for the general model (Equation 4) and Table 2 for the preferred specification (Equation 9).

Table 1 Results from linear version of (Equation 4) and comparison with unbiased estimates from (Equation 5) and (Equation 6).

Variable	Coefficient from (Equation 4)	T statistic 45-15, 5%=1.697, 10%=1.310	Unbiased estimate derived from (Equation 5) and (Equation 6)
C	10.98	-2.66	11.43
T	0.06	-0.47	0.05
LOG(IG)-LOG(IG(-1))	0.04	-0.54	-
LOG(INVN)	0.00	-1.59	-0.01
DP	-0.16	-1.20	-0.09
LOG(PRFR)-LOG(PRFR(-1))	-1.61	-1.27	-0.41
LOG(Q)-LOG(Q(-1))	4.93	5.16	2.86
LOG(R)-LOG(R(-1))	0.04	-0.09	0.08
LOG(TWI)-LOG(TWI(-1))	-0.39	-1.03	-0.63
LOG(IP(-1))	-0.50	-3.54	-0.47
LOG(IG(-1))	0.35	0.76	1.30
LOG(PRFR(-1))	0.83	2.18	0.74
LOG(Q(-1))	-0.97	1.50	-1.55
LOG(R(-1))	0.13	2.45	0.00
LOG(TWI(-1))	-0.24	0.64	-0.66
R-squared	0.6949	S.E. of regression	0.0722
Adjusted R-squared	0.5525	Durbin-Watson stat	1.8053

Table 2 Results from (Equation 9) and comparison with unbiased estimates from (Equation 5).

Variable	Coefficient from (Equation 9)	T statistic 45-15, 5%=1.697, 10%=1.310	Unbiased estimate derived from (Equation 5) and (Equation 6)
C	11.35	2.63	13.15
T	0.06	4.51	0.06
DP	-0.11	-1.91	-0.09
LOG(PRFR)-LOG(PRFR(-1))	-1.67	-3.20	-1.09
LOG(Q)-LOG(Q(-1))	4.49	4.64	3.29
LOG(R)-LOG(R(-1))	0.03	0.53	0.04
LOG(IP(-1))	-0.44	-4.59	-0.44
LOG(PRFR(-1))	0.48	1.72	0.49
LOG(Q(-1))	-0.78	-2.32	-1.35
LOG(R(-1))	0.12	2.90	0.08
R-squared	0.6479	S.E. of regression	0.0718
Adjusted R-squared	0.5573	Durbin-Watson stat	1.6118

4. The long run coefficients are computed as $-\alpha_1 * \beta_7 / \beta_7$ for IG_t, $-\alpha_2 * \beta_7 / \beta_7$ for Q_t, $-\alpha_3 * \beta_7 / \beta_7$ on $PRFR_t$, and $-\alpha_4 * \beta_7 / \beta_7$ on R_t in (Equation 4) and (Equation 9) where applicable. These are shown in Table 3.

Table 3 Long run elasticities from reduced form log specifications compared with unbiased estimates

Variable	(Equation 4)	Wald, χ^2 dof=1, crit 5% =3.84, 10%=2.71	(Equation 4) unbiased	(Equation 9)	Wald, χ^2 dof=1, crit 5% =3.84, 10%=2.7055	(Equation 9) unbiased
IG_t	0.70	2.24	2.76	na	na	na
Q_t	-1.95	2.73	-3.31	-1.78	3.43	-3.08
$PRFR_t$	1.67	10.21	1.57	0.28	4.29	1.12
R_t	0.26	8.17	0.01	1.10	8.75	0.17
TWI_t	-0.48	1.00	-1.40			

8. Discussion of results

The results of course face the usual limitations from the sample size. It is nonetheless held that the trade off is that the annual data capture the aggregate long run relationships as well or better than the less reliable and often purely interpolated quarterly data. The dynamics are expected to move relatively slowly in relation to the investment variables.

Given the nonstationary character of most of these aggregate variables in levels, the ECM estimates are reliant on cointegrating relationships as indicated by the absence of serial correlation in the residuals from Breusch Godfrey LM tests. Needless to say unit roots may remain in some lag structures which are unreachable here and call for further investigation. For the purpose of this paper though the ECM is found to be a valid model for investigating investment relationships.

The restrictions supported by model selection tests appear to show that cyclicality is not important however lead times are likely not to be well reflected. Similarly open aspects of the economy appear not to be important to aggregate private investment behaviour, or are not captured adequately through the trade weighted index measure. This does not sit well with the expectation of increased international investment flows associated with privatisation. Support for structural change between 1960 to 1984 and 1985 to 2005 is found from inclusion of an intercept dummy throughout the model selection but is not supported by the inclusion of slope dummies. This suggest that any difference between the two periods is due to other factors not captured here, or due to aspects of the role of public capital uncaptured in this model.

The average annual interest rate, return on capital and output variables are confirmed as entering the model of private investment. This confirms the conventional modelling approach taken in investigating investment behaviour although there are some puzzling anomalies in the results as shown in Table 3. These include the negative sign on the output elasticity which gets more so in the unbiased estimates however they are statistically significant only at the 10 per cent level of the Wald test. The interest rate elasticity is positive however the unbiased measures move closer to zero. These call for further investigation.

The investigation of endogeneities do not indicate great differences in sign or magnitude between reduced form and unbiased estimates. This supports the exogeneity of public investment at least at the aggregate level, as macroeconomic shocks at least as modelled here appear not to inform it over time. This is a key finding of the paper. However the story may be different at the industry level.

9. Conclusion

Great consequences were heralded for privatisation policy by its advocates prior to implementation. However these are not readily apparent at the aggregate level. This is confirmed by this investigation of the relationship between public and private investment at the aggregate level. In particular it is apparent that both public and private investment interact with the macroeconomic environment in ways that are not well understood and it is imperative that these be further investigated. It would be expected that privatisation would provide for enhanced investment outcomes which should be visible at the aggregate level and this is not suggested by the findings here by contrast with Monadjemi and Huh (1998). History is enough now to show that aggregate benefits from privatisation are not manifest. At the same time this study offers reasonably robust findings for a lack of impact of macroeconomic shocks on public investment over time.

While the findings offer little support for crowding out, nor do they inform sufficiently as to the process of crowding in. The absolute level of public investment has not declined and appears to be growing. The aggregate findings suggest strongly that the relationship between public and private investment are insufficiently captured here and further investigation of dynamics and endogeneity at industry level.

References

Aschauer David A 1989 Does public capital crowd out private capital? *Journal of Monetary Economics* V24 pp 171-188

Dowrick Steve 2000 The Resurgence of Australian productivity growth in the 1990s: Miracle or mirage Paper for the Australian Conference of Economists July

Eviews 5.1 2004 Quantitative Micro software LLC, Irvine California.

Florio, Massimo, 2004, *The great divestiture: Evaluating the welfare impact of the British privatizations*, 1979-1997, Cambridge and London: MIT Press

Forsyth, Peter ed 1992 *Microeconomic Reform in Australia* St Leonards N.S.W.: Allen & Unwin

Stephen King & Rodney Maddock 1996 *Unlocking the infrastructure : the reform of public utilities in Australia* St Leonards, N.S.W.: Allen & Unwin

Kmenta J 1986 *Elements of Econometrics* 2nd ed Macmillan New York

Monadjemi M S and H Huh 1998 Private and government investment: a study of three OECD countries *International Economic Journal* Vol 12, 2, Summer pp93-105.

Pesaran M H and R Smith 1998 Structural analysis of cointegrating VARs *Journal of Economic Surveys* Vol 12, 5, pp471-505.

Rossiter, Rosemary 2002 Structural cointegration analysis of private and public investment *International Journal of Business and Economics* Vol 1, No 1, pp59-67

Voss Graham M 2002 Public and private investment in the United States and Canada *Economic Modelling* V19 pp641-664

Appendix 1 Data description

Total public investment (IG_t)

Total public investment is derived from ABS spreadsheet 520402, 5204063, 5204066, 520467 and 520471. It is public gross fixed capital formation chain measure 2003-2004 annual from June 1960 to June 2005, including public corporations and general government at all levels of government. Public investment in ownership of dwellings is removed from it for comparability with the private investment series. This is done by obtaining the share of public dwellings in current public investment and removing that from the chain series for public investment. Public ownership transfer costs are not reported separately.

Inventories ($INVN_t$)

Inventories are current price changes in non farm inventories taken from ABS spreadsheet 5204067, deflated by the GDP deflator from ABS spreadsheet 520408, annual from June 1960 to June 2005. These data were used because the chain series for inventories in ABS spreadsheet 5204068 were provided only back to June 1975. They are almost identical to that series for later years. These are used as an indicator of cyclical movements in economic activity.

Total private investment (IP_t)

Total private investment is derived from ABS spreadsheet 520402, 5204063, 5204064 and 520471. It is the private gross fixed capital formation chain measure 2003-2004 annual from June 1960 to June 2005, with private investment in ownership of dwellings and ownership transfer costs removed. Ownership transfer costs include purchaser's transfer costs (stamp duties, legal fees etc.) and seller's transfer costs (real estate agents' commissions, legal fees etc.) in sale of assets which are both now counted in gross fixed capital formation (ABS Cat 5216.0 - Australian National Accounts: Concepts, Sources and Methods, 2000, Ch15).

Total investment (IT_t)

Total investment is taken from ABS spreadsheets 520402 and 5204063, derived from total gross fixed capital formation chain measure 2003-2004 annual from June 1960 to June 2005. Investment in ownership of dwellings and ownership transfer costs are removed from it.

Total capital stock (KT_t)

Total capital stock is derived from ABS spreadsheet 5204069. It is total end-year net capital stock minus dwellings, chain measure 2003-2004 annual from June 1960 to June 2005. ABS does not provide measures which fully separate total public and total private capital stocks over the period (McKenzie 2006).

Total profits (PRF_t)

Total profits is derived from ABS spreadsheet 5204057 and 520401. It is obtained as the annual share of the sum of current total gross operating surplus and total gross mixed income in current total income. This is taken to represent the share of profits in gross domestic income chain measure 2003-2004 annual from June 1960 to June 2005. For the earlier years no separate figures are available for gross operating surplus and gross mixed income.

Profit rate ($PRFR_t$)

The profit rate is obtained as the ratio of total profits to total net capital stock, the latter obtained as above.

Total income (Q_t)

Total income is taken from Australian Bureau of Statistics (ABS) spreadsheet 520401 for gross domestic income chain measure 2003-2004 annual from June 1960 to June 2005.

Interest rate (R_t)

The interest rate is an annual average of the monthly average of the daily cash rate as provided by the Reserve Bank of Australia (RBA) in Table F01 and historically to July 1959. Some changes in RBA methodology over time are unlikely to much affect the consistency of the annual series for the purpose here. For some periods the comparable cash rate was not directly available. It was supplemented with monthly 90day rate from Jan 1990 to June 1992, and 30day rate from July 1992 to June 1998 which appeared little different for the purpose of annual averaging. The intention of the measure is to give an annual overview of the level of interest rates from year to year from the perpective of planning investment expenditures.

Exchange rate (TW_t)

The exchange rate is the terms of trade for goods and services from the Reserve Bank of Australia (RBA) *Australian Economic Statistics 1949–50 to 1996–97* Occasional Paper No. 8 Table 1.14a, for June 1950 to June 1997. This was spliced with the RBA real trade weighted index quarterly figures for June, from June 1996 to June 2005.

Wages (W_t)

Wages are derived from ABS spreadsheet 5204057 and 520401. The series is obtained as the annual share of the sum of current total employment compensation in current total income. This is taken to represent the share of wages in gross domestic income chain measure 2003-2004 annual from June 1960 to June 2005.

Appendix 2 Stationarity tests

The stationarity properties of the regression variables were examined from some ADF tests conducted in Eviews. The tests are understood to be of limited power in relatively short samples. The results are given in Eviews according to the Schartz Information Criterion (SIC) test to discover the order of any autorogressive process in the variable. The ADF test was condusted for the level with a constant, level with a constant and a trend, and first and second differences of the variable. The outputs are available on request from the author. These are reported in Table 4.

Table 4 Stationarity of variables: tests of null hypothesis of a unit root

Unit root in: **Variable:**	**Levels with:** **Constant** By t test	**Levels with:** **Constant and trend** By t test	**First differences:** By t test	**Second differences:** By t test
DW_t (dwellings)	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	3	0	4	3
IG_t	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	0	0	0	3
$INVN_t$	Reject at 5% level	Reject at 5% level	Reject at 5% level	Reject at 5% level
p	1	1	1	3
IP_t	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	6	1	0	5
IT_t	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	0	0	0	5
KT_t	Not reject	Not reject	Not reject	Reject at 5% level
p	2	2	1	0
OTC_t (ownership transfer costs)	Not reject	Reject at 5% level	Reject at 5% level	Reject at 5% level
p	0	0	1	2
PRF_t	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	0	0	0	2
$PRFR_t$	Reject at 10% level	Not rejected	Reject at 5% level	Reject at 5% level
p	0	0	0	2
Q_t	Not reject	Not reject	Reject at 10% level	Reject at 5% level
p	0	0	0	0
R_t	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	0	0	1	3
(TW_t)	Not reject	Not reject	Reject at 5% level	Reject at 5% level
p	4	4	3	7
W_t	Not reject	Not reject	Not reject	Reject at 5% level
p	1	1	0	1

Notes: Number of lags *p* selected by SIC up to 9 lags is shown in brackets after test result.

Appendix 3 Model selection

Table 5 Summary of results from specification search from (Equation 4)

	Variable: Dep var $\Delta lnIP_t$	C	T	$\Delta lnIG_t$	ΔlnQ_t	Δln $PRFR_t$	Δln R_t	Δln TW_t	Ln IG_{t-1}	Ln Q_{t-1}	Ln $PRFR_{t-1}$	Ln R_{t-1}	Ln TW_{t-1}	Ln IP_{t-1}	Ln $INVN_t$	DP	R^2 adj	SE	LL	DW	F	LLR test
Specification	(Equation 4	β_0	β_1	β_2	β_3	β_4	β_5	β_6	$\beta_7*\alpha_1$	$\beta_7*\alpha_2$	$\beta_7*\alpha_3$	$\beta_7*\alpha_4$	$\beta_7*\alpha_5$	β_7	β_8	β_9						
		10.98	0.06	0.04	4.93	-1.61	0.04	-0.39	0.35	-0.97	0.83	0.13	-0.24	-0.50	0.00	-0.16	0.5525	0.0722	63.54	1.81	4.88	
	t	2.14	3.80	0.19	4.59	-2.64	0.57	-1.45	1.48	-1.99	2.34	2.82	-1.03	-4.43	-0.16	-2.43						
1	H_0 $\beta_9 = 0$	5.64	0.04	0.06	4.71	-1.29	0.05	-0.34	0.15	-0.37	0.72	0.10	-0.10	-0.51	-0.01	-	0.4818	0.078	59.50	1.58	4.15	χ^2, 1 =8.08
	t	1.13	2.74	0.26	4.09	-2.01	0.71	-1.18	0.62	-0.82	1.90	2.18	-0.43	-4.20	-1.02							H_0 rej
2 drop $INVN_t$	H_0 $\beta_8 = 0$	11.37	0.06	0.04	4.88	-1.65	0.04	-0.37	0.35	-1.01	0.81	0.13	-0.25	-0.49	-	-0.17	0.57	0.07	63.52	1.81	5.42	χ^2, 1 =0.04
	t	2.56	4.16	0.17	4.84	-2.95	0.57	-1.53	1.51	-2.32	2.53	2.87	-1.07	-4.97		-2.70						H_0 not rej
3 drop both TW_t	H_0: $\alpha_5 = \beta_6 = 0$	12.65	0.06	-0.01	4.47	-1.71	0.04		0.30	-1.14	0.66	0.13		-0.47		-0.14	0.56	0.07	61.70	1.64	6.06	χ^2, 1 =3.64
	t	2.87	4.64	-0.03	4.54	-3.22	0.57		1.29	-2.66	2.15	2.90		-4.77		-2.33						H_0 not rej

Table 6 Summary of search down from specification 3

	Variable:																		
	Dep var $\Delta lnIP_t$	C	T	$\Delta lnIG_t$	ΔlnQ_t	$\Delta ln PRFR_t$	$\Delta ln R_t$	$Ln IG_{t-1}$	$Ln Q_{t-1}$	$Ln PRFR_{t-1}$	$Ln R_{t-1}$	$Ln IP_{t-1}$	DP	R^2 adj	SE	LL	DW	F	LLR test
	(Equation 4	β_0	β_1	β_2	β_3	β_4	β_5	$\beta_7 * \alpha_1$	$\beta_7 * \alpha_2$	$\beta_7 * \alpha_3$	$\beta_7 * \alpha_4$	β_7	β_9						
4 drop both R_t	H_0: $\alpha_4 = \beta_5 = 0$	15.19	0.063	0.09	4.61	-2.17		0.33	-1.26	0.1		-0.4	-0.09	0.47	0.08	56.42	1.37	5.40	χ^2, 2 =10.55
	t	3.286	4.17	0.38	4.60	3.92		1.30	2.75	0.39		4.22	1.41						H_0 rej
5 drop both $PFRF_t$	H_0: $\alpha_3 = \beta_4 = 0$	7.2	0.03	0.188	1.17		0.1	-2.11	-0.29		0.037	-0.21	0.01	0.13	0.10	45.17	1.87	1.74	χ^2, 2 =33.07
		1.6	1.5	0.64	1.32		0.07	0.74	0.53		0.81	2.01	0.12						H_0 rej
6 drop both Q_t	H_0: $\alpha_2 = \beta_3 = 0$	-0.7	0.022	0.07		0.44	0.11	0.09		1.13	0.13	-0.44	-0.03	0.27	0.09	48.99	1.64	2.79	χ^2, 2 =25.42
		0.27	3.41	0.27		1.08	1.51	0.39		3.0	2.41	3.49	-0.54						H_0 rej
7 drop both IG_{t-1}	H_0: $\alpha_1 = 0$	11.35	0.06		4.49	-1.67	0.034		-0.77	0.48	0.12	-0.44	-0.11	0.56	0.18	60.31	1.61	7.15	χ^2, 2 =2.78
	t	2.64	4.51		4.64	3.20	0.53		2.32	1.72	2.9	4.6	1.9						H_0 not rej