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Essays on Investment: Cycles, Imbalances and Convexity

Thesis submitted to the University of Dublin, Trinity College, in fulfilment of the requirements for the degree of Ph.D.

November 2007

John Colin Hunt

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Dedication

This work is dedicated with love to Nuala,

and

to the memory of Peter and Brian.

Declaration

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Summary

This thesis is a collection of essays on public investment. The thesis is introduced in Chapter One which addresses the motivation for the thesis and outlines the structure of the document.

Chapter Two addresses the topic of cyclicality and discretion in Irish fiscal policy. In particular, we show that the level and nature of cyclicality varies across different expenditure components and we introduce a new definition of feasible discretion to take account of political imperatives in budgetary management. We find that overall government expenditure is acyclical and is most heavily influenced by a fiscal parsimony objective. Automatic stabilisers are efficiently countercyclical, feasible discretionary government consumption growth is orthogonal to economic fundamentals while feasible discretionary investment growth is strongly procyclical. Using official growth forecasts, we show that feasible discretionary investment growth is deliberately pro-cyclical.

Chapter Three addresses the interaction of public and private capital stocks. We show for most developed countries that there is a long-term equilibrium relation between public and private capital and that investment growth of both varieties carries momentum from year to year. We find that imbalances in the relation of public and private capital are more likely to arise on foot of relatively inadequate public investment and are most likely to be corrected through a public sector adjustment. Private capital tends towards weak exogeneity. Given the source of most imbalances and the relative scale of the capital stocks, the elimination of relative investment deficits is likely to become increasingly challenging. Maintenance of the long-run equilibrium relation between the public and private capital stocks in the majority of countries will necessitate a marked increase in government capital spending and/or a sustained decline in the private capital stock.

Chapter Four addresses the relation of investment costs and investment activity levels in twenty OECD economies with particular reference to the presence of convexity. We show that the only convincing evidence of convexity in investment costs is presented by the construction sector and only relative to equipment investment. For both total and private investment, cost growth actually declines, albeit at a diminishing pace, as investment momentum falls. Government investment cost growth is non-responsive to

government investment activity. Potential reverse causality issues arise in relation to construction and equipment investment with evidence presented that prices actually increase during periods of declining activity.

Chapter Five concludes and offers pointers for future research.

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Chapter One

Introduction

1.1 Motivation

This thesis consists of a collection of essays on public investment and factors affecting its efficacy. The role of investment in growth is the subject of a large body of theoretical and empirical literature while the particular role of public investment and its productivity has attracted increasing amounts of research interest in recent years. This thesis builds on this work by exploring factors that may limit, impair or counter the beneficial impact of public investment on a country's economic prospects. Specifically, we consider the cyclicality of public investment, the relation of private and public investment and the impact on investment costs of changing levels of investment activity.

1.2 Structure

The first empirical paper, Chapter Two, considers the issue of the cyclicality of Irish fiscal policy[1]. We introduce a new definition of discretionary spending which takes account of both legal obligations and political imperatives to isolate spending decisions over which policy-makers exercise what we style feasible discretion. Our data set was constructed using Irish Government and OECD publications. First, we explore the nature of the long-term relation between government spending and overall economic activity using cointegration techniques. We then employ an error correction mechanism to identify the short-run relation of the cyclical and various sub-components of government expenditure. Our analysis points to marked procyclicality in feasible discretionary government investment. Moreover, official growth forecasts are more statistically significant in the relevant regressions than actual growth outturns. This finding leads us to the conclusion that, not only is government feasible discretionary investment procyclical in Ireland, it is deliberately so.

The focus of the thesis shifts away from Ireland in Chapter Three which explores the relation of public and private investment in 20 developed economies. We estimate public and private capital stocks and consider their long-term equilibrium relations. We examine the nature of short-term public and private investment dynamics using vector error correction mechanisms, vector autoregression techniques and impulse response functions. We also estimate the source and size of capital stock imbalances, highlight

[1] A previous version of this chapter was presented at the Irish Economic Association Annual Conference in April 2005 and it was published in the Economic and Social Review, Winter 2005.

which category of investment carries the burden of adjustment in the majority of cases considered and estimate the speed of convergence to the public/private capital stock equilibrium using a half-life decay formula.

The evidence suggests that there is a long-term equilibrium relation between the public and private capital stocks in the great majority of developed countries considered. This chapter also presents solid empirical support for the hypothesis that any existing imbalance between private and public capital stocks is a driver of annual stock changes. Moreover, the output of our VECM analysis reveals that any imbalances in the relation of the public and private capital stocks of a country are more likely to be corrected through public-sector rather than private-sector adjustment. The chapter's estimated imbalance findings allow us to conclude that capital imbalances are more likely to arise due to a relative deficiency in the public capital stock.

The final paper is presented in Chapter Four which examines whether the neo-classical assumption of convexity in investment adjustment costs is empirically justified in 20 developed economies over the 1960 to 2003 period. The presence of convexities in investment adjustment costs would imply that adjustment should be dispersed and gradual rather than seek to eliminate any capital deficits expeditiously. Clearly, appreciating the nature of adjustment costs is critical to the determination of efficient investment policies and their optimal implementation. In this chapter we investigate the nature of the relation between incremental investment and the cost of investment in total, government, private-sector, construction and equipment investment using OLS and TSLS regressions. We also consider the relative convexity of government and private investment costs and finally the relative convexity of equipment and construction costs. We show that the neo-classical assumption that investment adjustment costs are convex has limited validity at the aggregate level. There is no evidence that aggregate investment costs accelerate as real investment expenditure growth becomes increasingly rapid in the OECD countries analysed as a unit. In fact, the analysis conducted shows that concavity at the total and private aggregate level arises during periods of disinvestment.

Chapter Five concludes by summarizing the main findings of the thesis and by identifying some potential avenues for future research.

Chapter Two

Discretion and Cyclicality in Irish Budgetary Management 1969-2003

2.1 Introduction

Irish fiscal policy management has fallen into sharper focus in recent years, particularly in the advent and aftermath of membership of Economic and Monetary Union. A growing emphasis on budgetary management is something of a global phenomenon with dissent about the conduct of monetary policy fading as a general consensus emerges in favour of monetary stability. Taylor (2000) points out that the environment in which discretionary counter-cyclical fiscal policy can be considered has fundamentally changed on the back of two factors: Monetary policy has become more transparent and more reactive to changes in both inflation and output; and the emergence of new normative macroeconomics with an emphasis on evaluating policy rules.

Ireland is an interesting subject for study as fiscal outturns were wildly volatile over the course of the past three decades. Given the health of the public finances since the mid 1990s, the fiscal policy decision-making process is unlikely to have been distorted by pressure arising from the Maastricht criteria and, subsequently, the Stability and Growth Pact.

The existing body of work will be augmented by an analysis of the interaction between cyclicality, political choices and decomposed government expenditure for Ireland over the course of the 1969-2003 period. This chapter highlights the cyclicalities of Irish government consumption, current transfers and investment adjusted to take account of both legal obligations and political imperatives and also examines the efficiency of automatic stabilisers. Attention is paid to the rank of government investment spending within the budgetary-formation process.

2. 2 Theoretical backdrop

The neo-classical view that government spending's share of GDP should behave countercyclically is intuitively appealing given that procyclical responses of fiscal policy exacerbate underlying fluctuations in consumption and output. Traditional Keynesian analysis suggests that fiscal policy should be countercyclical with government increasing spending and reducing taxes during recessionary periods and adopting an opposite stance during upturns. Under such a policy, there would be a positive correlation between tax rates and output while the correlation between government spending and output would be negative.

However, tax-smoothing models, inspired by Barro (1979), posit that policy should remain neutral over the cycle. This approach predicts a constant tax rate, procyclical revenues and countercyclical deficits. Execution of this policy would manifest itself in zero correlation between tax rates and output and spending and output. Taylor (2000) is supportive of this view suggesting that it would be reasonable in the present US context for discretionary fiscal policy to be saved explicitly for longer-term issues, requiring less frequent changes. OECD economies seem to follow this prescription with Backus, Kehoe and Kydland (1995) showing that the correlations in these countries between government consumption and output appear to be low in absolute value.

Further underpinning is provided by Eichenbaum (1997) who claims that there is widespread agreement that countercyclical discretionary fiscal policy is neither desirable nor politically feasible. Such a claim should be regarded as something of an overstatement particularly in light of the aggressive countercyclicality of US fiscal policy during the most recent economic downturn. Indeed, given concerns about the potential inertia of monetary policy at times when nominal interest rates are low and given the real threat of deflation, the desirability and feasibility of countercyclical discretionary fiscal policy have been enhanced in the early years of this decade. Recent experiences also erode Eichenbaum's observation that practical debates about stabilisation policy revolve almost exclusively around monetary policy.

2.2.1 Previous Empirics

In conflict with the theoretical foundations, a number of empirical studies have found that procyclicality is, in fact, commonplace. Gavin and Perotti (1997), in a study of Latin American countries, show that fiscal policy is procyclical and suggest that this phenomenon is due to the difficulties experienced by developing nations in accessing international credit flows during cyclical downturns. Their work was supported by Talvi and Vegh (2000) who suggest that procyclical fiscal policy is so pervasive in the world economy that it should arguably be regarded as the rule rather than the exception. In a sample of 56 countries, they show that fiscal policy is acyclical among G7 countries, procyclical among non-G7 industrial countries and strongly procyclical among developing economies.

In explaining this puzzle, they introduce a political distortion into the standard optimal fiscal policy model which encapsulates the pressures which arise to increase public spending on the back of budget surpluses. Tornell and Lane (1999) refer to this

phenomenon as the voracity effect where powerful groups attempt, in response to a positive revenue shock, to grab a greater share of national wealth. With this political adjustment, Talvi and Vegh (2000) suggest that an optimal policy response to positive shocks in the tax base will involve both decreasing taxes and raising spending with the opposite responses recommended during negative tax base shocks. Their model predicts that politically-constrained optimal fiscal policy is procyclical.

Previous work suggests that Ireland's budgetary management has similarities with the developing country behaviour identified by Talvi and Vegh (2000). Lane (1998) shows that Irish fiscal policy is not generally countercyclical and that different elements of public expenditures are actually procyclical.

Evidence is also available for the US showing that even among G7 members, there are layers of government which demonstrate countercyclical and acyclical responses to evolving national income patterns. Sorensen, Wu & Yosha (2001) found that budget surpluses of local and, in particular, state governments are procyclical, smoothing disposable incomes and consumption of state residents. They find that expenditures are weakly procyclical while revenues are strongly procyclical.

While the literature is relatively rich in relation to the cyclicality of fiscal policy, little attention has been paid to the correlation of expenditure and the economic cycle. The standard neo-classical assumption is that government expenditure is exogenously determined (Blanchard and Fisher (1989)). Lane (2003a) notes, if government spending is endogenised, that the optimal comovement between government consumption and private consumption depends on the degree of substitutability in utility between these two items. Government consumption would be expected to move countercyclically if public and private expenditure components are substitutes.

Lane (1998) points out that government investment should be the most acyclical component of fiscal policy given that public investment projects are typically multi-year projects with long planning lead times and substantial completion lag times. In fact, in a study of the OECD, Lane (2003a) shows that government investment is the most procyclical component of government spending although government consumption is also procyclical.

2.3 Methodology

The sample period for this analysis is 1969 to 2003. This chapter decomposes total government spending initially into government consumption, government investment and government current transfers and then into their respective discretionary and non-discretionary components. Further adjustments are made to produce levels that are styled feasible discretionary government consumption, investment and current transfers. Feasible discretionary expenditure is defined as expenditure which is totally subject to government policy choice taking account of both legal obligations and political imperatives.

Of course, at the limit practically all government expenditure is discretionary. Notionally, a government can choose not to pay public servants, to renege on its national debt obligations or to abolish the social security regime. However, certain legal obligations are imposed on government by virtue of the need to service the national debt, to fulfil EU membership funding requirements and to provide for the pay and pensions of certain public office holders. Adjusting for these sums produces expenditure amounts over which the government can exercise what we style perfect discretion. However, the political dimension to fiscal policy management and the finite horizon of the elected policymaker impose a further constraint on the level of discretion.

Feasible discretionary government investment is taken as total government capital expenditure less transfers. These include the costs associated with the pre-funding of future pension liabilities, loans to and investments in state enterprises and investments in international bodies such as the International Monetary Fund and the European Bank for Reconstruction and Development.

Perfect discretionary government consumption is taken as total government current expenditure adjusted for the costs of servicing and managing the national debt, the annual contribution to the budget of the European Union and other costs which the government is legally compelled to fund such as the remuneration of the judiciary and the head of state. These adjustments are only sufficient to reduce government consumption to its perfect discretionary level. Political imperatives demand that the government must finance cost of living increases for both public servants and welfare recipients. These too represent an effective prior charge on the government's budget. This reality is accounted for by making a further adjustment to perfect discretionary

consumption. Thanks to the welfare adjustment, this manipulation has the effect of excluding automatic stabilisers from consideration in this component.

Enhanced wage bills driven by year-on-year increases in the numbers employed in the public sector and pay increases exceeding the rate of consumer price inflation are treated as feasible discretionary consumption items. Increases in the social welfare budget adjusted for changes in the number of recipients that are greater than CPI awards are also included in the analysis as feasible discretionary current transfers. The residual of perfect discretionary consumption and transfers is included in our analysis as automatic stabilisers. Specifically, our automatic stabilisers category includes CPI and recruitment-adjusted changes in the public sector pay bill and the CPI-adjusted welfare bill.

Using the short-run model outlined below, we separately regress feasible discretionary government consumption, investment, current transfers and automatic stabilisers on the set of independent variables. As well as providing insights on the relative cyclicality of government expenditure components, the model's output can be interpreted to establish a ranking of the relative importance of spending categories in the budget-formation process.

2.3.1 Modeling Framework

Total government spending converges to some proportion of output over the long term. This relationship can be captured by the following equation:

$$g_t = \theta + \gamma D_t + y_t \tag{2.1}$$

where g is the log of real government spending

y is the log of real GDP

θ is a long-run parameter

and D_t is a dummy variable that takes the value 1 between 1977 and 1986 inclusive[2].

[2] During this period, Irish fiscal policy was characterized by excessive spending growth, burdensome budget deficits and an escalating public debt. At the end of the period, the budget deficit stood at 12% of GNP while the National Debt/GNP ratio reached 122%. 1987 marked the start of a programme of fiscal rectitude that returned order to the public finances.

The dummy variable is included to capture the effect of periods of irresponsible fiscal policy management.

The level of government spending as a share of output is largely exogenously determined with the private sector playing a critical role and is subject to shifts depending on political preferences. Barro (1990) shows that a growth-maximising government will set its share of gross national product to equal the share it would get if public services were a competitively supplied input of production. He also demonstrates that the relative size of government that maximises utility exceeds the value that maximises the growth rate only if the elasticity of substitution between the amount of capital per worker and the quantity of public services provided to each household-producer is greater than unity. This share of gross national product is smaller if the government is using taxes to finance other types of spending. Variations in government consumption's share of gross national product correlate negatively with growth and savings rates.

In the short run, government spending evolves along a path, given by Equation 2.2, which is influenced but not solely determined by the relationship between government expenditure and total output. The previous year's government spending growth rate, real GDP growth and a set of political dummy variables are also used as explanatory variables. Following from Equation 2.1:

$$\Delta g_t = \mu - \delta(g_{t-1} - y_{t-1} - \theta - \gamma D_{t-1}) + \rho_1 \Delta g_{t-1} + \rho_2 \Delta y_t + \beta Z_t + \varepsilon_t \qquad (2.2)$$

where Δg is real growth in government expenditure,

Δy is real GDP growth,

Z is a set of dummy variables capturing the impact of political factors,

μ is a drift term and

ε_t is a stochastic error term.

This can be re-written as:

$$\Delta g_t = \mu + \delta\theta + \delta\gamma D_{t-1} - \delta(g_{t-1} - y_{t-1}) + \rho_1 \Delta g_{t-1} + \rho_2 \Delta y_t + \beta Z_t + \varepsilon_t \qquad (2.3)$$

All real variables are calculated using the GDP deflator. The political and temporary factors include the stage of the electoral cycle, the political complexion of the government and the security of the government's parliamentary position. The constant term in the dynamic equation is $\mu + \delta\theta$ being a combination of the drift term μ and the long-run parameter θ. The coefficient on the dummy variable is $\delta\gamma$. It is the product of the error-correcting (ECM) coefficient δ and the policy irresponsibility parameter γ.

2.4 Empirical Results

Appendix I describes the sources of the data. Appendix II presents the results of tests, all of which confirm stationarity, on the relevant variables for the presence of unit roots using the Augmented Dickey-Fuller test. Appendix III addresses the issue of simultaneity and reports the results of a series of two-stage least squares regressions. These allow us to conclude that endogeneity is not an issue and that the original estimators are consistent.

We first look at the long run before turning to issues of cyclicality. The long-run relationship between government expenditure and GDP is explored using least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. In Table 2.1, we present the results of a regression of the difference of real government expenditure and real output (g-y) on the irresponsibility dummy, thus making the theoretically attractive imposition of a unitary long-run coefficient in the regression of real government expenditure on real output. The irresponsibility dummy is statistically significant at the 1% level and is, as expected, positively signed. While we are unable to reject the hypothesis of a unit root in the residuals using the Augmented Dickey Fuller (ADF) test, further testing using the Ng-Perron and the Elliott-Rothenberg unit root tests points to stationarity in the residuals. Additional testing is warranted given the low power of the ADF test and the superior power and size properties of the Ng-Perron and Elliott-Rothenberg tests.[3] It is intuitively consistent to argue that there must be some long-term, non-spurious relationship between government expenditure and output and on foot of our cointegration findings, we include an error-correcting mechanism in our evaluation of the short term.

[3] See Elliott, Rothenberg and Stock (1996) and Ng and Perron (2001).

Turning to the short-run, we examined the relationship between the various measures of government expenditure outlined above and a number of independent variables using least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. In Table 2.3, we present the results of our first set of short-run regressions with total government spending taking the role of the dependent variable.

Our results suggest that the rate of economic growth has little impact on overall government spending growth as the estimated coefficient of DY is insignificantly different from zero in each of the regressions. This allows us to reject the hypothesis of cyclicality in Irish government expenditure. However, the inclusion of a variable which captures the relationship between government expenditure and GDP (GGDP) as an independent variable has a positive impact on the regression's explanatory power. In each case, the estimated coefficient of GGDP is significantly different from zero with the null of $\delta = 0$ being rejected at a p-value of 0.01 when a dummy variable designed to capture the impact of a period of fiscal policy irresponsibility (SHIFT) is included. The GGDP variable is negatively signed. This result is intuitively appealing as it suggests that the greater the size of government, the less willing policymakers are to engage in further spending expansionism. The regression results in Table 2.3 clearly indicate that the desire to shrink the size of government spending or the imperative of fiscal parsimony has a far more significant role to play in explaining momentum in total government spending than the vagaries of the economic cycle.

The introduction of the SHIFT dummy variable should be significant. A priori, we would expect government spending growth to be higher in the years 1977 to 1986 given the deterioration in the quality of fiscal management which occurred in that period. As expected, the SHIFT variable has a marked and positive impact on the regression's explanatory power and it is statistically significant at the 5% level. Following logic, the SHIFT dummy is positively signed. [4]

[4] Where lagged dependent variables are used throughout this paper, we eschew reporting a Durbin-Watson d test statistic as that test assumes that the regression model does not include lagged values of the dependent variable. In its stead, the Breusch-Godfrey Lagrange Multiplier test is used. The null hypothesis of this test is that there is no serial correlation in the residuals.

Overall, the evidence in Table 2.3 suggests that total government expenditure growth is acyclical with the imperative of fiscal parsimony, as measured by the GGDP variable, having a significant influence on spending momentum. Moreover, overall spending growth tends to be higher during periods of policy irresponsibility.

However, the results generated for overall government expenditure may well be camouflaging conflicting cyclical momentum among its component parts. Each of these components is examined in turn. It is reasonable to assume that automatic stabilisers will be the component of public expenditure which is most markedly countercyclical. The evidence of our analysis is strongly supportive of this contention as presented in Table 2.4. The GDP growth rate (DY) is statistically significant in each of the regressions presented in the table and, in all but the simplest model, is significant at the 1% level. Moreover, the coefficient is negatively signed throughout pointing to strong countercyclicality in the automatic stabilising component of government expenditure. The simplest model with DY as the sole independent variable reports a low DW d statistic (1.38) that highlights the risk of excluded variable specification bias. The inclusion of the fiscal parsimony imperative (GGDP) as an independent variable augments the explanatory power of the regression with the adjusted R^2 increasing to 0.31. The GGDP variable is strongly significant at the 1% level in two of the regressions reported and is negatively signed in each regression suggesting that larger government output shares serve to restrain the efficacy of automatic stabilisers.

The addition of the SHIFT dummy does not augment the explanatory power of the regression and the variable is statistically insignificant. This result is intuitive as it suggests that bouts of budgetary irresponsibility have little impact on the automatically stabilizing elements of government spending. Overall, the evidence of this set of regressions is strongly supportive of the view that automatic stabilisers are efficiently counter-cyclical in an Irish context with the level of economic growth being the prime determinant of growth in this expenditure component. The size of government is of secondary importance in this expenditure category.

In Tables 2.5 and 2.6, we present the findings of a series of regressions with feasible discretionary government consumption and current transfers as the respective regressands. We would have expected to uncover some countercyclicality in the case of feasible discretionary government consumption at least. This variable can be thought of as non-automatic government consumption: it seems reasonable to assume that policymakers would make use of this expenditure category to smooth the cycle.

However, the results of both sets of regressions suggest that economic growth rates (DY), the fiscal parsimony imperative (GGDP), momentum indicators (LDV) and the irresponsibility dummy have extremely poor explanatory power. In fact, in no instance in these sets of regressions can we reject the null hypothesis that the true coefficient is zero. Our analysis suggests that real growth in feasible discretionary consumption and feasible discretionary current transfers is orthogonal to economic fundamentals. [5]

The results for feasible discretionary government investment are presented in Table 2.7. As discussed earlier, this should be the component of government expenditure that demonstrates the least amount of cyclicality due to its multi-year nature in terms of both planning and delivery.

The results of the two simplest regressions with DY alone and DY and GGDP used as regressors provide conflicting signals in terms of the statistical significance of the independent variables. Moreover, DW statistics which lie below and within (respectively) the zone of indecision at the 5% significance level alert us to the possible presence of positive autocorrelation in the error terms. We suspect that we are dealing with a case of excluded variable specification bias. With the inclusion of a lagged dependent variable, the null hypothesis of no serial correlation is not rejected using the results of the Breusch-Godfrey Lagrange Multiplier test. Moreover, the lagged dependent variable is significant at the 10% level when it is included with the DY and GGDP variables. However, its inclusion impacts negatively on the significance of the GGDP variable and we can no longer reject the null hypothesis that the true value of the GGDP coefficient is equal to zero. This result encourages us to risk specification bias by dropping the GGDP variable from the regression.

This move leaves us with two strongly significant independent variables in the form of DY and LDV with the null that the true value of the coefficients are zero being rejected at a p-value of 0.002 and 0.000 respectively. The evidence suggests that feasible discretionary government investment is impacted by a different set of influences than overall government expenditure. The results of the limited regression suggest that

[5] We tested for the impact of different definitions of discretion by running a set of regressions where all changes in both public sector pay and welfare payments rather than those payments in excess of inflation are treated as discretionary. The results show that adjusted current transfers are negatively correlated with the output growth rate and the government share of GDP at the 1% level. Adjusted consumption is negatively correlated with the relationship between government spending and output at the 1% level. These regressions point to the presence of a cyclical element in inflation and also suggest that spending growth in these expenditure categories above an inflation-proofing level is not influenced by economic considerations.

feasible discretionary government investment is strongly procyclical and carries momentum from the previous year. The latter result is understandable given the multi-year nature of government capital formation planning.

Most interest, however, centres on the cyclicality result. Given the relative size of the estimated coefficients (1.53 in the case of real GDP growth and 0.39 in the case of the lagged dependent variable), our results suggest that current economic activity is a considerably more potent influence on the resources made available for feasible discretionary investment than multi-year budgeting. As such, the results can be interpreted as indicating a short-termist approach on the part of domestic policymakers to government-funded fixed capital formation.

2.5 The Impact of Forecasts

Given the evidence of procyclicality in feasible discretionary government investment reported earlier, we conducted a series of regressions to test the relative importance of actual and forecast growth rates in determining this component of public expenditure. The results are presented in Tables 2.8 and 2.9.

In Table 2.8, the actual growth rate is excluded as an independent variable while the forecast growth rate, given by the mean of the Department of Finance's and the OECD's published forecast growth rates, is included. This is a reasonable approach to take as forward spending decisions, as presented in the annual Budget, are based on growth projections rather than actual outturns. The results presented in Table 2.8 report that the forecast growth rate is statistically insignificant as an explanatory variable where overall government spending, feasible discretionary consumption expenditure and feasible discretionary current transfers are the dependent variables. This suggests that growth forecasts have little bearing on budget decisions in relation to overall expenditure, transfer payments or feasible discretionary consumption.

However, the forecast growth rate is statistically significant at the 1% level where real growth in automatic-stabilising expenditure is the dependent variable. When the actual growth rate is added as an explanatory variable, as shown in Table 2.9, the forecast growth rate is no longer statistically significant while the actual growth outturn is significant at the 1% level. With the coefficient being negatively signed, this result is intuitively appealing: automatic stabilising expenditure growth should have an inverse relationship with economic growth and should be more potently affected by actual

rather than forecast activity levels. The fiscal parsimony variable is also significant at the 1% level where the actual growth rate is excluded and at the 5% level where it is included as an independent variable. It is negatively signed suggesting that the efficacy of automatically stabilizing expenditure is adversely impacted by excessive government expenditure.

In the regression where feasible discretionary government investment is the dependent variable, the mean growth forecast and the lagged dependent variable are the only statistically significant independent variables. Moreover, the null hypothesis that the true value of the forecast coefficient equals zero is rejected at a p-value of 0.02. The adjusted R^2 in the case of this regression where feasible discretionary investment growth is the dependent variable in Table 2.8 is the highest encountered in the analysis conducted for this chapter at 0.43. This result is intuitively appealing as it is most sensible for policymakers to plan investment spending levels on the basis of growth forecasts. When we add the actual growth rate as an explanatory variable, the adjusted R^2 eases slightly to 0.41 while the mean forecast growth rate becomes the only statistically significant explanatory variable. We reject the null hypothesis that the true value of the forecast coefficient equals zero at a p-value of 0.01.

The strength of the relationship between actual feasible discretionary investment growth and forecast GDP growth levels suggests that policymakers have great faith in their own forecasts. The size of the coefficient of forecast growth, at 3.23 where the actual growth outturn is included as an independent variable, suggests, once again, that feasible discretionary investment spending is strongly procyclical. The significance of the various forecasts combined with the size of the coefficients suggests that this sub-component of government expenditure is deliberately procyclical.

Our analysis offers the conclusion that the procyclicality of Irish feasible discretionary government investment arises not on the back of forecast failures but rather by design. Policymakers appear to devote resources to capital investment when economic activity generates such resources, thus pointing us towards the conclusion that capital investment is the residual in the budgetary process.

2.6 Conclusions

The evidence in this chapter suggests that while Irish government expenditure is in aggregate acyclical, there are substantial differences in the cyclicality of the sub-components. Overall government expenditure appears to be more strongly influenced by considerations of fiscal probity rather than the rate of GDP growth. However, our analysis of disaggregated expenditures suggests that this overall result serves to camouflage the co-existence of marked pro- and counter-cyclicality. Automatic stabilisers report a pronounced counter-cyclicality which is appealing from an efficiency viewpoint and underpinned by theoretical considerations. Two of the new sub-components of expenditure which we examined, namely feasible discretionary government consumption and feasible discretionary current transfers show no evidence of any cyclicality. In fact, there seems to be no relation between these series and any of the independent variables we identified for this chapter: We conclude that momentum in these areas where policymakers have real discretion and full freedom to manoeuvre is orthogonal to economic fundamentals.

Our analysis points to marked procyclicality in feasible discretionary government investment. Moreover, official growth forecasts are more statistically significant in the relevant regressions than actual growth outturns. This finding leads us to the conclusion that, not only is government feasible discretionary investment procyclical, it is deliberately so. The Department of Finance does appear to have believed prevailing consensus forecasts over the period under study. The evidence we present strongly supports the contention that when Irish policymakers have the money, they spend it on feasible discretionary investment. As a consequence, we can conclude that government investment has been the residual in the Irish budgetary process over the 1969 to 2003 period.

This approach to the allocation of capital resources imposes clear short-term restraints on the effective management of the economic cycle and could, through a stop-start approach to government-funded capital formation, reduce the economy's sustainable growth potential. The hope must be that recent changes to the capital resource allocation structure, outlined below, will reduce the pronounced procyclicality of feasible discretionary government investment.

In Budget 2004, the Irish Government announced the introduction of rolling five-year multi-annual envelopes for all investment areas and committed itself to allocating 5% of

GNP to Exchequer-funded capital investment over the period 2004-2008. Moreover, greater flexibility in the allocation of capital resources between years has been promoted by allowing individual Government Departments to carry over to the following year any unspent Exchequer capital allocations up to a maximum of 10% of each annual capital subhead. The commitment to allocate 5% of (forecast) GNP should significantly reduce the cyclicality of government investment over the years ahead.

Appendix 2.A Data Sources & Issues

Social security data were drawn from the annual Statistical Abstract of Ireland and from the annual Statistical Report of the Department of Social and Family Affairs.
National accounts data were taken from the CSO's annual National Income & Expenditure publications.
Fiscal data were drawn from the Department of Finance's annual Finance Accounts.
Numbers employed in the public sector were sourced from the Labour Force Survey and provided by the Economic and Social Research Institute.
Growth forecasts are taken from the OECD's June Economic Outlook and individual country report publications and the Department of Finance's Economic Review and Outlook publications.
Live register data were provided by Datastream.

Fiscal years: Until 1974, Irish fiscal accounts were prepared on the basis of the old fiscal year, April 6th to April 5th. 1975 was the first year in which calendar-based data were made available. Adjustments are made to previous years' data using spending growth trends to produce calendar estimates for the period 1969 to 1974.

Euro changeover: In 1999, Ireland joined Economic and Monetary Union and from 2001 all data releases are denominated solely in euro. The necessary adjustment for comparability is made by converting euro amounts into punts at the irrevocable fixed rate at which Ireland joined the single currency.

Establishment of An Post and Telecom Eireann: These entities were previously part of central government and their expenditures were treated as government consumption and investment until 1984. Amounts spent by the predecessor of these bodies were excluded for the period 1969 to 1984 for comparability purposes.

No explicit discretionary/non-discretionary capital split for 1969 – 1973: To overcome this data deficiency we assume that the average discretionary/non-discretionary capital expenditure split for the period 1969-1973 was the same as that in the 1975-1977 period.

Number of Social Welfare Beneficiaries: This data series is incomplete. A proxy was built taking the total number of recipients of old-age pensions, retirement pensions,

blind pensions, disability benefits, unemployed benefit (as measured by the live register) and the total number of children for whom children's allowances/benefits are paid.

Appendix 2.B Unit Root Tests

The results of our unit root tests are presented in Table 2.2. For all the variables presented here other than real GDP growth (DY) and real feasible discretionary current transfers growth (DTRANFD), we can confidently reject the null hypothesis that there is a unit root and each of these time series is stationary. In the cases of real government expenditure growth (DG), growth in automatic stabiliser expenditure (DAUTOCT) and real feasible discretionary government consumption growth (DCONFD), the null hypothesis can be rejected at the 1% level. In the case of real feasible discretionary investment growth (DINVFD), the null hypothesis of a unit root can be rejected at the 5% level while the null can be rejected at the 10% level in the case of real feasible discretionary current transfers growth (DTRANFD). In relation to real GDP growth, the test results suggest that this time series is borderline non-stationary with a p-value of 0.115. However, it is reasonable to treat DY as a stationary variable given theoretical support: GDP growth rates do have a mean-reverting tendency.

Appendix 2.C Instrumental Variable Estimation

In order to investigate the possible existence of endogeneity between economic growth and growth in overall government expenditures, a regression using two-stage least squares (TSLS) was run. The results are presented in Table 2.10. The lagged value of economic growth is employed as the instrumental variable. The TSLS output is broadly similar to that generated by the OLS regression allowing us to conclude that endogeneity is not an issue and that the original estimators are consistent. TSLS regressions were also performed for each of the government expenditure subcomponents considered in the chapter. Again, the results, generated by both OLS and TSLS procedures are broadly similar. The greatest divergence in results is reported for automatic stabilising expenditure (AUTO) where the significance of the instrumental variable (one year lag of economic growth) falls outside the 10% level compared to the 1% reported for actual economic growth. This result is in line with expectations given the intended simultaneity of changes in economic activity and automatic-stabilising expenditure by government.

Chart 2.1 - Government Share of GDP

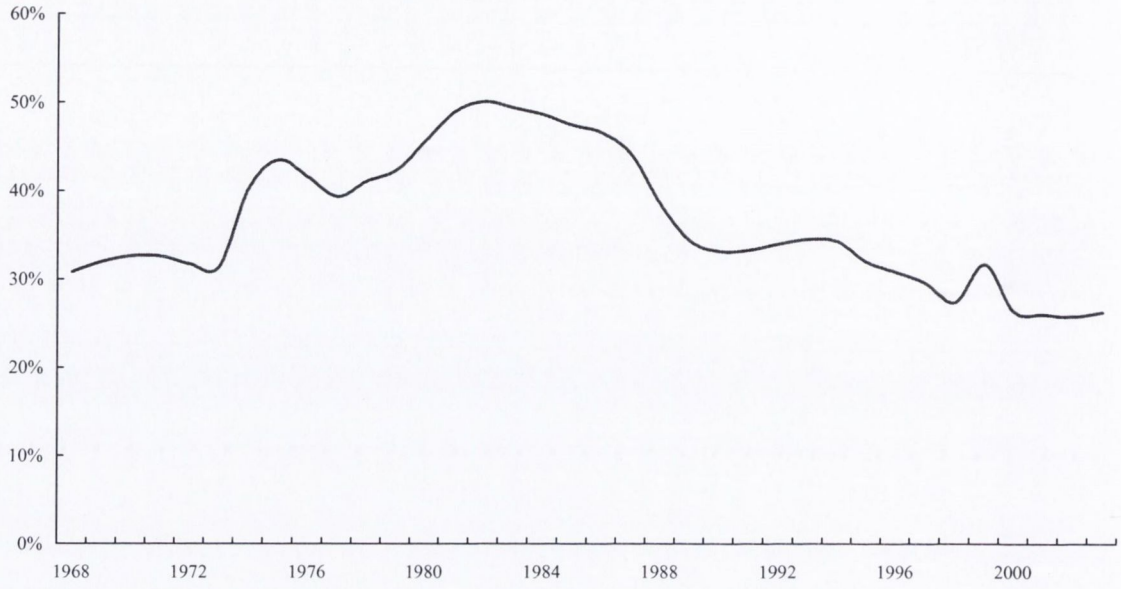


Chart 2.2 - GDP Growth Rates

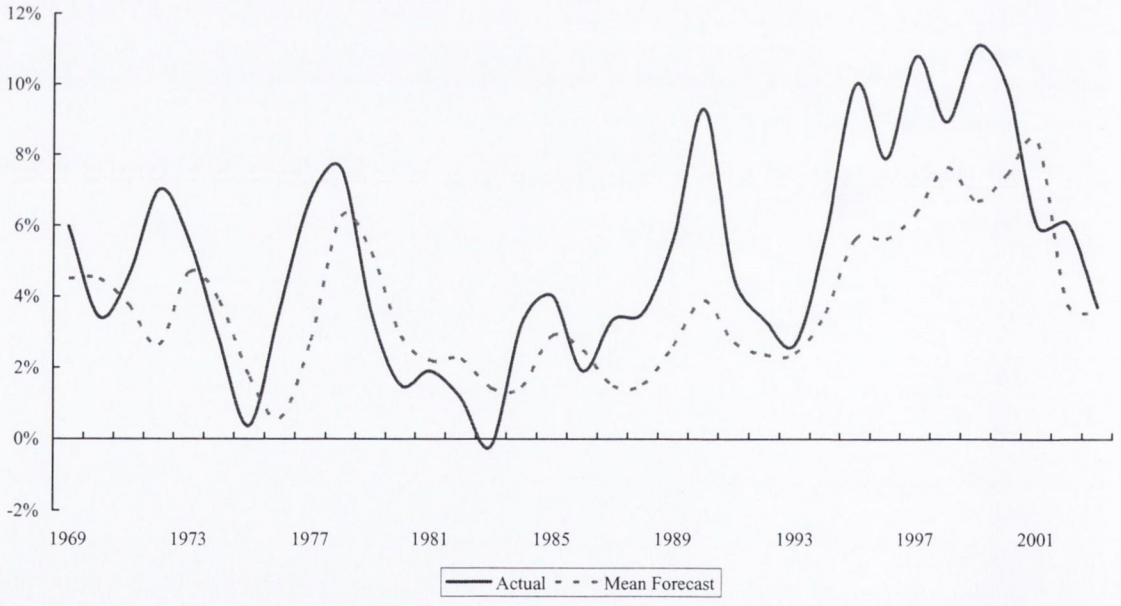


Chart 2.3 - Government Spending Growth and the Cycle

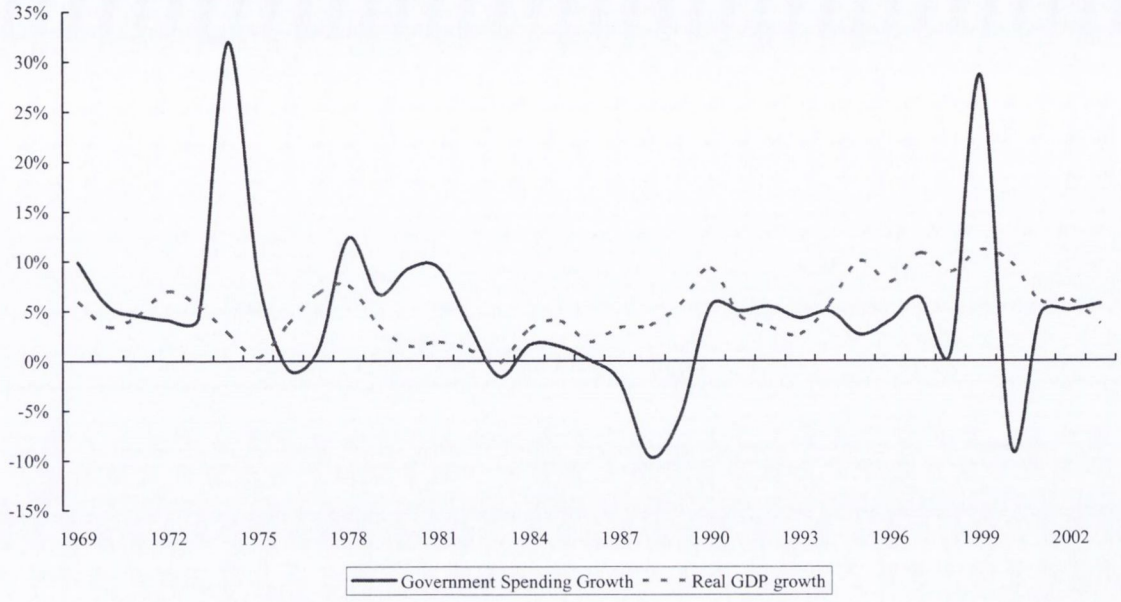


Chart 2.4 - Feasible Discretionary Investment and the Cycle

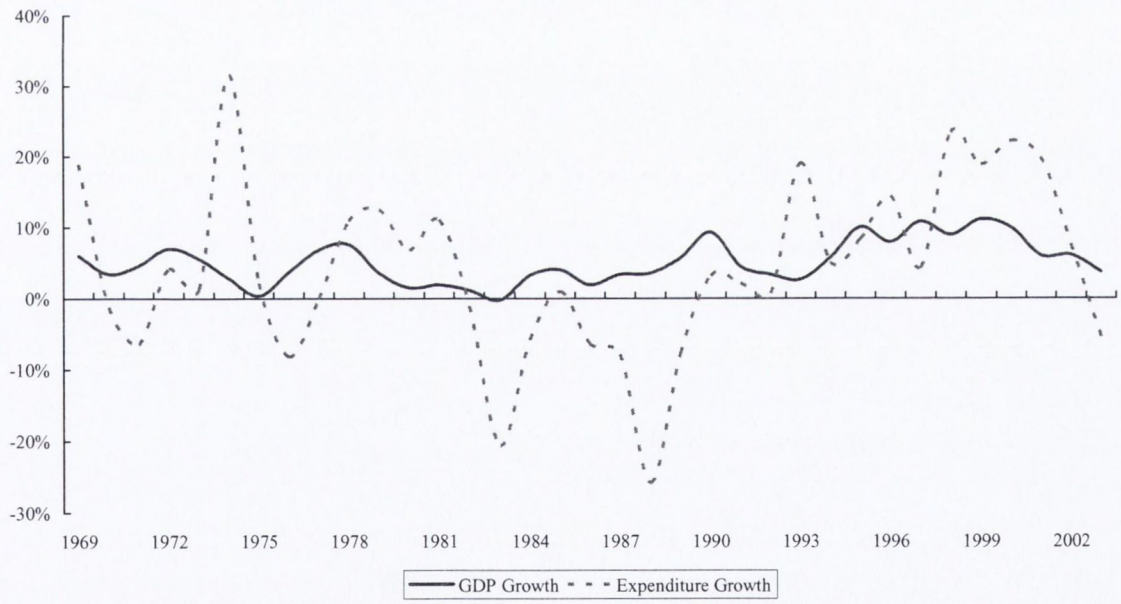


Chart 2.5 - Automatic Stabilisers & the Cycle

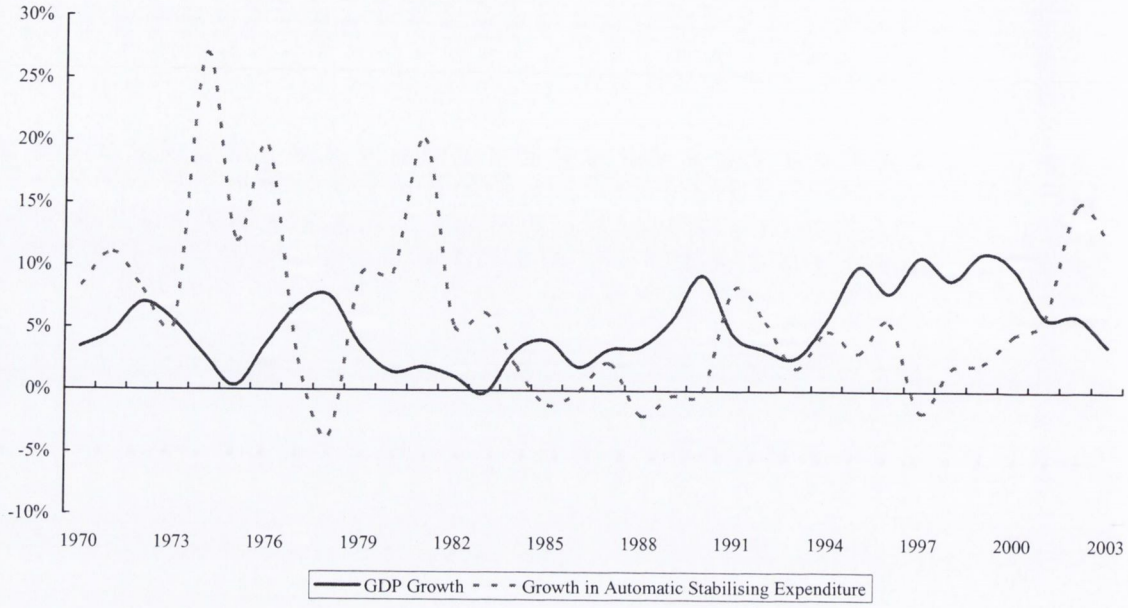


Table 2.1: Long-Run Difference Relationship with Irresponsibility Dummy

	C	SHIFT	$RBAR^2$	DW	ADF RES	NG RES	ERS RES
g-y	-1.12	0.34	0.55	0.68			
	(23.96)	(5.15)***			(-2.38)	(-9.11)	(2.99)
	[0.00]	[0.00]			[0.15]		
Critical Values	1%				-3.6329	-13.80	1.87
	5%				-2.9484	-8.10	2.97
	10%				-2.6130	-5.70	3.91

Notes: t values in parentheses; p-values in square brackets. Independent variable g-y is the difference between the logs of real government spending and real GDP. SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. ADF refers to the Augmented Dickey-Fuller test, NG to the Ng-Perron Modified Unit Root Test, and ERS to the Elliott-Rothenberg Point Optimal Unit Root Test.

Sources: Central Statistics Office, Department of Finance

Table 2.2: Short-Run Cyclicality - Unit Root Tests

Augmented Dickey-Fuller Test		DY	DG	DAUTOCT	DTRANFD	DCONFD	DINVFD
		(-2.540)	(-5.661)	(-3.775)	(-2.929)	(-5.737)	(-3.658)
		[0.1152]	[0.0000]	[0.0072]	[0.0561]	[0.0000]	[0.0095]
Critical Values	1%	-3.639	-3.639	-3.646	-3.724	-3.646	-3.639
	5%	-2.951	-2.951	-2.954	-2.968	-2.954	-2.951
	10%	-2.614	-2.614	-2.616	-2.617	-2.616	-2.614

Notes: t values in parentheses; p-values in square brackets. DY is the real GDP growth rate; DG is the percentage change in real government expenditure; DINVFD is the percentage change in real feasible discretionary government investment; DCONFD is the percentage change in real feasible discretionary government consumption; DTRANFD is the percentage change in real feasible discretionary current transfers; DAUTOCT is the percentage change in residual discretionary consumption and transfers.

Sources: Central Statistics Office, Department of Finance

Table 2.3: Short-Run Cyclicality - Total Government Spending

	C	DY	GGDP	SHIFT	RBAR2	F	DW
	0.04	0.20			-0.02	(0.19)	1.97
(1)	(1.24)	(0.46)				[0.66]	
	[0.22]	[0.65]					
	-0.11	-0.48	-0.18		0.09	(2.65)	2.03
(2)	(1.53)	(0.85)	(1.98)*			[0.09]	
	[0.13]	[0.40]	[0.06]				
	-0.26	-0.48	-0.31	0.08	0.16	(3.22)	2.08
(3)	(2.66)	(0.75)	(2.76)***	(2.69)**		[0.04]	
	[0.01]	[0.46]	[0.01]	[0.01]			

Notes: t values in parentheses; p-values in square brackets. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variable: DG is the percentage change in real government expenditure. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively.

Sources: Central Statistics Office, Department of Finance

Table 2.4: Short-Run Cyclicality - Automatic Stabilisers

	C	DY	GGDP	LDV	SHIFT	$RBAR^2$	F	DW	BG-LM
	0.11	-0.86				0.12	(5.50)	1.38	
(1)	(3.45)	(2.41)**					[0.026]		
	[0.002]	[0.020]							
	-0.05	-1.57	-0.19			0.31	(8.55)	1.86	
(2)	(0.94)	(4.23)***	(3.27)***				[0.001]		
	[0.352]	[0.000]	[0.003]						
	-0.06	-1.42	-0.19	0.19		0.33	(6.17)		0.20
(3)	(1.33)	(3.17)***	(3.20)***	(1.77)*			[0.002]		
	[0.19]	[0.004]	[0.003]	[0.08]					
	-0.06	-1.42	-0.18	0.19	-0.01	0.30	(4.47)		0.21
(4)	(0.69)	(3.13)***	(2.34)**	(1.74)*	(0.07)		[0.006]		
	[0.50]	[0.004]	[0.03]	[0.09]	[0.95]				

Notes: t values in parentheses; p-values in square brackets. BG-LM is the p-value from the Breusch-Godfrey Lagrange Multiplier test for first order serial correlation in the residuals. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; DY is the real GDP growth rate; LDV is the value of the dependent variable lagged by one year. SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variable: DG is the percentage change in real residual discretionary consumption and transfers. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively.

Sources: Central Statistics Office, Department of Finance, Department of Social and Family Affairs, ESRI.

Table 2.5: Short-Run Cyclicality - Feasible Discretionary Consumption

	C	DY	GGDP	LDV	SHIFT	RBAR2	F	DW	BG-LM
	-14.43	140.22				-0.02	(0.32)	2.08	
(1)	(0.99)	(0.93)					[0.57]		
	[0.33]	[0.36]							
	19.60	296.13	41.40			-0.03	(0.57)	2.15	
(2)	(0.77)	(1.04)	(0.93)				[0.57]		
	[0.45]	[0.31]	[0.36]						
	23.50	52.30	49.26	-0.08		-0.05	(0.47)		0.59
(3)	(0.73)	(0.96)	(0.87)	(0.94)			[0.71]		
	[0.47]	[0.35]	[0.39]	[0.35]					
	-1.74	357.52	28.47	-0.09	13.03	-0.08	(0.41)		0.60
(4)	(0.05)	(0.94)	(0.62)	(0.96)	(0.82)		[0.80]		
	[0.96]	[0.36]	[0.54]	[0.35]	[0.42]				

Notes: t values in parentheses; p-values in square brackets. BG-LM is the p-value from the Breusch-Godfrey Lagrange Multiplier test for first order serial correlation in the residuals. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; DY is the real GDP growth rate; LDV is the value of the dependent variable lagged by one year. SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variable: DCONFD is the percentage change in real feasible discretionary government consumption.

Sources: Central Statistics Office, Department of Finance, Department of Social and Family Affairs, ESRI.

Table 2.6: Short-Run Cyclicality - Feasible Discretionary Current Transfers

	C	DY	GGDP	LDV	SHIFT	$RBAR^2$	F	DW	BG-LM
	-7.53	-82.67				-0.03	(0.04)	2.05	
(1)	(0.74)	(0.55)					[0.84]		
	[0.46]	[0.59]							
	37.13	119.69	53.74			-0.05	(0.29)	2.10	
(2)	(0.96)	(0.70)	(0.99)				[0.75]		
	[0.35]	[0.49]	[0.33]						
	43.91	194.56	65.60	-0.06		-0.08	(0.24)		0.91
(3)	(0.85)	(0.72)	(0.88)	(0.88)			[0.87]		
	[0.40]	[0.48]	[0.39]	[0.39]					
	27.69	195.83	52.08	-0.07	8.32	-0.11	(0.18)		0.90
(4)	(0.51)	(0.72)	(0.71)	(0.88)	(0.66)		[0.94]		
	[0.61]	[0.48]	[0.48]	[0.38]	[0.51]				

Notes: t values in parentheses; p-values in square brackets. BG-LM is the p-value from the Breusch-Godfrey Lagrange Multiplier test for first order serial correlation in the residuals. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; DY is the real GDP growth rate; LDV is the value of the dependent variable lagged by one year. SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variable: DTRANFD is the percentage change in real feasible discretionary current transfers.

Sources: Central Statistics Office, Department of Finance, Department of Social and Family Affairs, ESRI.

Table 2.7: Short-Run Cyclicality - Feasible Discretionary Investment

	C	DY	GGDP	LDV	SHIFT	$RBAR^2$	F	DW	BG-LM
	-0.04	1.70				0.15	(6.90)	1.36	
(1)	(0.94)	(2.63)**					[0.013]		
	[0.36]	[0.01]							
	-0.27	0.65	-0.28			0.27	(7.14)	1.42	
(2)	(2.43)	(0.81)	(2.06)**				[0.003]		
	[0.021]	[0.423]	[0.047]						
	-0.18	0.96	-0.16	0.29		0.30	(5.69)		0.60
(3)	(1.45)	(1.14)	(1.10)	(1.83)*			[0.003]		
	[0.156]	[0.263]	[0.351]	[0.077]					
	-0.06	1.53		0.39		0.28	(7.52)		0.59
(4)	(1.55)	(3.45)***		(3.90)***			[0.002]		
	[0.132]	[0.002]		[0.000]					
(5)	-0.40	0.91	-0.34	0.24	0.10	0.35	(5.51)		0.55
	(2.30)	(0.94)	(1.62)	(2.07)**	(2.52)**		[0.002]		
	[0.03]	[0.36]	[0.12]	[0.05]	[0.02]				

Notes: t values in parentheses; p-values in square brackets. BG-LM is the p-value from the Breusch-Godfrey Lagrange Multiplier test for first order serial correlation in the residuals. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; DY is the real GDP growth rate; LDV is the value of the dependent variable lagged by one year; SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variable: DINVFD is the percentage change in real feasible discretionary government investment. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively.

Sources: Central Statistics Office, Department of Finance, Department of Social and Family Affairs, ESRI.

Table 2.8: Impact of Forecasts on Spending Decisions

	C	GGDP	LDV	DYMEAN	SHIFT	$RBAR^2$	BG-LM
DG	-0.29	-0.34	0.04	-0.74	0.09	0.12	0.45
(1)	(2.28)	(2.24)**	(0.19)	(0.88)	(2.59)**		
	[0.03]	[0.03]	[0.85]	[0.38]	[0.02]		
DAUTOCT	-0.13	-0.23	0.22	-1.77	0.03	0.16	0.60
(2)	(1.53)	(3.15)***	(1.68)	(2.87)***	(0.79)		
	[0.14]	[0.004]	[0.11]	[0.01]	[0.44]		
DCONFD	0.32	66.10	-0.09	706.97	-1.11	-0.07	0.42
(3)	(0.55)	(0.78)	(1.01)	(0.96)	(0.09)		
	[0.58]	[0.45]	[0.32]	[0.35]	[0.93]		
DINVFD	-0.28	-0.19	0.13	2.80	0.05	0.43	0.96
(4)	(1.62)	(0.97)	(1.89)*	(2.50)**	(1.05)		
	[0.12]	[0.34]	[0.07]	[0.02]	[0.30]		
DTRANFD	14.23	26.07	-0.05	-79.60	9.73	-0.12	0.86
(5)	(0.35)	(0.54)	(0.90)	(0.21)	(0.65)		
	[0.73]	[0.59]	[0.37]	[0.84]	[0.52]		

Notes: t values in parentheses; p-values in square brackets. Independent variables; GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; LDV is the value of the dependent variable lagged by one year; DYMEAN is the average of the forecast growth rates of the Department of Finance and the OECD; and SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variables: DG is the percentage change in real government expenditure; DAUTOCT is the percentage change in real residual discretionary consumption and transfers; DCONFD is the percentage change in real feasible discretionary government consumption; DINVFD is the percentage change in real feasible discretionary government investment; and DTRANFD is the percentage change in real feasible discretionary current transfers. ***,** ,* denote significance at the 1, 5 and 10 percent levels respectively.

Sources: Central Statistics Office, Department of Finance, OECD

Table 2.9: Impact of Forecasts on Spending Decisions (Control with Actual Growth Rates)

	C	GGDP	DY	LDV	DYMEAN	SHIFT	$RBAR^2$	BG-LM
DG	-0.28	-0.33	-0.36	0.01	-0.33	0.08	0.10	0.31
(1)	(1.96)	(2.11)**	(0.39)	(0.07)	(0.26)	(1.77)*		
	[0.06]	[0.04]	[0.70]	[0.94]	[0.80]	[0.09]		
DAUTOCT	-0.08	-0.21	-1.29	0.17	-0.42	0.01	0.28	0.42
(2)	(1.01)	(2.65)**	(2.87)***	(1.38)	(0.82)	(0.19)		
	[0.32]	[0.01]	[0.01]	[0.18]	[0.42]	[0.85]		
DCONFD	25.95	62.79	175.56	-0.10	515.51	2.89	-0.10	0.43
(3)	(0.46)	(0.75)	(0.79)	(0.97)	(0.95)	(0.20)		
	[0.65]	[0.46]	[0.44]	[0.34]	[0.35]	[0.84]		
DINVFD	-0.27	-0.19	-0.35	0.10	3.23	0.04	0.41	0.86
(4)	(1.58)	(0.95)	(0.33)	(0.85)	(2.88)***	(0.84)		
	[0.13]	[0.35]	[0.75]	[0.41]	[0.01]	[0.41]		
DTRANFD	1.54	20.19	379.14	-0.07	494.63	18.18	-0.15	0.25
(5)	(0.04)	(0.40)	(0.83)	(0.88)	(0.68)	(0.84)		
	[0.97]	[0.69]	[0.41]	[0.39]	[0.50]	[0.41]		

Notes:

t values in parentheses; p-values in square brackets. Independent variables; GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; LDV is the value of the dependent variable lagged by one year; DY is the actual real GDP growth rate;DYMEAN is the average of the forecast growth rates of the Department of Finance and the OECD; and SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. Dependent variables: DG is the percentage change in real government expenditure; DAUTOCT is the percentage change in real residual discretionary consumption and transfers; DCONFD is the percentage change in real feasible discretionary government consumption; DINVFD is the percentage change in real feasible discretionary government investment; and DTRANFD is the percentage change in real feasible discretionary current transfers. ***,** ,* denote significance at the 1, 5 and 10 percent levels respectively.

Sources: Central Statistics Office, Department of Finance, OECD

Table 2.10: Short-Run Cyclicality - IV Estimation

	C	DY	GGDP	SHIFT	LDV	RBAR2	F
GOV	-0.26	-0.48	-0.31	0.08		0.16	(3.22)
(1)	(2.66)	(0.75)	(2.76)***	(2.69)**			[0.04]
OLS	[0.01]	[0.46]	[0.01]	[0.01]			
GOV	-0.29	-1.33	-0.38	0.08		0.08	(2.92)
(2)	(2.52)	(1.13)	(2.69)**	(1.87)*			[0.05]
TSLS	[0.02]	[0.27]	[0.01]	[0.07]			
AUTO	-0.06	-1.42	-0.18	-0.01	0.19	0.30	(4.47)
(3)	(0.69)	(3.13)***	(2.34)**	(0.07)	(1.74)*		[0.006]
OLS	[0.50]	[0.004]	[0.03]	[0.95]	[0.09]		
AUTO	-0.08	-2.09	-0.24	-0.002	0.10	0.24	(2.34)
(4)	(0.85)	(1.59)	(1.76)*	(0.06)	(0.43)		[0.08]
TSLS	[0.40]	[0.12]	[0.09]	[0.95]	[0.67]		
CON	-1.74	357.52	28.47	13.03	-0.09	-0.08	(0.41)
(5)	(0.05)	(0.94)	(0.62)	(0.82)	(0.96)		[0.80]
OLS	[0.96]	[0.36]	[0.54]	[0.42]	[0.35]		
CON	3.84	514.50	42.21	13.38	-0.11	-0.09	(0.23)
(6)	(0.06)	(0.68)	(0.48)	(0.54)	(0.53)		[0.92]
TSLS	[0.96]	[0.51]	[0.63]	[0.59]	[0.60]		
TRAN	27.69	195.83	52.08	8.32	-0.07	-0.11	(0.18)
(7)	(0.51)	(0.72)	(0.71)	(0.66)	(0.88)		[0.94]
OLS	[0.61]	[0.48]	[0.48]	[0.51]	[0.38]		
TRAN	9.24	-253.43	10.45	7.95	-0.02	-0.14	(0.16)
(8)	(0.08)	(0.21)	(0.07)	(0.20)	(0.10)		[0.96]
TSLS	[0.94]	[0.84]	[0.94]	[0.84]	[0.92]		
INV	-0.06	1.53			0.39	0.28	(7.52)
(9)	(1.55)	(3.45)***			(3.90)***		[0.01]
OLS	[0.13]	[0.002]			[0.000]		
INV	-0.12	2.80			0.36	0.18	(8.27)
(10)	(2.38)	(3.03)***			(2.31)**		[0.001]
TSLS	[0.02]	[0.01]			[0.03]		

Notes: t values in parentheses; p-values in square brackets. Independent variables: GGDP is the difference between the log of real government expenditure and real GDP lagged by one year; DY is the real GDP growth rate; SHIFT is a dummy variable which captures periods of fiscal irresponsibility and takes a value of 1 from 1977 to 1986 inclusive. ***, **, * denote significance at the 1, 5 and 10 percent levels respectively.

Chapter Three

The Interaction of Public and Private Capital: A Study of 20 OECD Members 1960-2003

3.1 Introduction

The economic impact of public investment has attracted increased amounts of interest in recent years. While productivity measurement disputes remain unresolved, there has been a tendency amongst researchers in this area to focus on the dynamics of public investment. However, there are two primary categories of investment, public and private, which have an impact on any country's activity levels and they are subject to some variance in influences, with the electoral cycle and fiscal policy likely to play a greater role in influencing the former. In contrast, private sector investment is likely influenced by a smaller set of mainly economic and commercial factors. It is possible that one type of investment, namely public investment, can have a countervailing impact on the other as highlighted in the crowding-out hypothesis (Buiter (1977)). This chapter explores the nature of the relation between public and private investment. It considers the long-term equilibrium, or steady-state relations between public and private capital stocks, examines the nature of short-term public and private investment dynamics, estimates the source and size of capital stock imbalances, that is deviations from the steady-state relations, and highlights which category of investment carries the burden of adjustment in the majority of cases considered.

The OECD area is an interesting sample to study in this regard given the quality of data available, broadly equivalent access to international financial markets amongst its members and the spread of its income levels and economic performances. The chapter adds to the existing body of work by estimating the cointegrating equations of public and private capital stocks using Dynamic Ordinary Least Squares (DOLS), by considering the nature of the short-term relations of public and private investment, by distinguishing between the investment types as sources of capital imbalances or deviations from the steady state, by identifying which investment type is more likely to make necessary steady-state-seeking adjustments and by estimating the speed of convergence using a half-life decay formula.

This chapter is organised as follows: Section 3.2 presents a short review of the literature; section 3.3 discusses data considerations; the methodology used in the chapter is presented in section 3.4; our empirical results are outlined and discussed in section 3.5; while section 3.6 concludes.

3.2 Literature Review

Taking a long-term perspective, Barro (1991), in a study of 98 countries, has presented results consistent with the hypothesis that the typical country comes close to the quantity of public investment that maximises the growth rate. In addition, once the total investment to GDP ratio is held constant, there is no separate effect on growth from the breakdown of total investment between public and private components. In the shorter term, momentum in public and private sector investment is clearly subject to different influences. As Hulten and Petersen (1984) point out, the demand for capital by a cost-minimising firm is a function of the user cost of capital, the price of non-capital inputs and the desired level of output. The first-order condition for optimal investment for the private entity is that marginal cost equals marginal return. Several factors prevent this transparent mechanism from being readily applicable in the public sector. These include political and institutional constraints as well as the fact that cost minimisation is but one factor in the public investment decision-making process.

According to Baxter and King's (1993) general equilibrium analysis, there are two opposing forces determining the response of private capital to an increase in public capital: the negative impact of the public capital financing cost on private sector resources; and the positive effect of an increase in public capital on the marginal productivity of private capital. In essence, an increase in public investment produces countervailing crowding-in and crowding-out effects. The impact of the latter effect is diluted by the openness of an economy to international flows. For instance, in the case of a monetary union, crowding-out effects cannot be transmitted by the interest rate channel and are more likely to manifest themselves in higher construction costs and wages.

León-González and Montolio (2003) found that the impact of public investment is subject to controversy because of the trade-off between the positive effects of public capital as a factor of production and the potentially negative effects derived from the taxes necessary to finance public capital. Bosca, Cutanda and Escriba (2000) found that both public and private capital have followed criteria of efficient provision, characterised by an absence of systematic or significant differences in the rates of return to public and private capital in 17 OECD countries.

Voss (2002), in a study of the US and Canada, demonstrated that there is no evidence of crowding in due to complementarities between public and private investment with both countries experiencing a crowding-out impact to private investment from public investment innovations. The latter finding is in direct conflict with the results of Aschauer's (1989b) analysis for the US where he found a strongly positive relation between productivity and the ratio of the public/private capital stock with a 1% increase in the public capital stock raising multifactor productivity by potentially 0.39%.

Meanwhile, Kamps (2005), in a comprehensive paper on the dynamic effects of public capital in the OECD, concluded that public and private capital are long-run complements for the vast majority of countries sampled while the short-run evidence is mixed[6]. Perotti (2004b) found that the effect of government spending shocks and tax cuts on GDP have become substantially weaker over time and these effects, particularly on private investment, tend to be negative in the post-1980 period.

This chapter is novel in showing that short-term imbalances in the long-term equilibrium relation between public and private capital stocks are more likely to be the result of an inadequate public capital stock, in demonstrating that momentum in public capital is more likely to respond to the existence of such imbalances and that public investment responds positively to innovations in private investment. In essence, our analysis suggests that public investment is less exogenous than private investment. Moreover, given the source of imbalances and the relative scale of the capital stocks, the maintenance of the long-term, equilibrium relation necessitates either a marked increase in government investment spending and/or an activity-damaging sustained decline in the private capital stock in the majority of countries considered.

3.3 Data

The sample period for this analysis is 1960 to 2003. Following Kamps (2004) we derive estimates of the public and private capital stocks in 20 OECD countries using the perpetual inventory method based on a geometric depreciation pattern. Real capital growth rates are sourced from the OECD database. In arriving at our estimates for capital stocks, we have assumed that public capital assets depreciate by 4% per annum,

[6] Kamps (2005) concentrates on the dynamic effects of public capital on employment, real GDP and private capital. The main findings are that shocks to public capital tend to have significant positive output effects, that there is little evidence for supernormal returns to public capital, that public and private capital are long-run complements in the majority of countries and that the long-run response of employment to a shock to public capital is statistically insignificant.

that non-residential private assets depreciate by 8% per annum, while residential private assets depreciate by 1.5% per annum. The private asset depreciation rate for each country is calculated by reference to the split in residential/non-residential asset values in the base year. The estimated values of the public and private capital stocks are generated by the following expression:

$$K_{t+1} = (1-\delta)^t K_1 + \sum_{i=0}^{t-1} (1-\delta)^i I_{t-i} \tag{3.1}$$

where K_t is the real capital stock at the beginning of period t

I_t is real gross investment in period t

and δ is a geometric depreciation rate.

Following the methodology employed by Jacob, Sharma and Grabowski (1997) and Kamps (2004), due to the absence of official stock data, estimates of the initial capital stock for 1960 are generated by the construction of an artificial investment series for the 1860-1959 period. This series is built on the assumption that gross investment increased by 4% across the twenty countries considered in this chapter, a level comparable to the average growth rate from 1960. While this assumption is less than satisfactory, it is essential to the construction of estimates of the capital stock. However, concerns about the validity of the assumption are assuaged by noting that the impact of the original capital stock declines with time while Kamps (2004) reports a sensitivity analysis which suggests that such an assumption "does not affect the dynamics of the resulting capital stock series to a large extent".

Charts 3.1a to 3.1t present graphical representations of the relation of the public and private capital stocks over the period under consideration (1960 – 2003) for each country. Each graph includes the public and private capital stocks relative to GDP as well as the ratio of the private capital stock to the public capital stock (PK/GK). In the majority of countries considered, there was a marked decline in the relative size of the government capital stock over the 1960 – 2003 period. However, there are a large number of exceptions to the general trend with the relative size of the government capital stock increasing in a number of Scandinavian countries (Norway, Sweden and Finland), Italy and in three of the EU15 Cohesion Fund recipient countries (Greece, Portugal and Spain) where domestic public capital resources were boosted through the 1990s by European Union investment funding. In the case of both Belgium and Germany, earlier trend increases in the relative size of the public capital stock reversed from the mid to late 1980s. Interestingly, Ireland is the only country of the EU15

Cohesion Fund recipients which reported an ongoing decline in the relative size of the public capital stock through the 1990s reflecting, in the main, very high growth in private capital formation in the 1994 – 2000 period.

3.4 Empirical Methodology

Barro (1990) derives an equilibrium relation between public capital and output, and therefore, an implicit steady-state relation between the public and private capital stocks. While subject to some differing short-term factors, these stocks should move in tandem over the longer-term. The existence of such a steady-state relation among a set of non-stationary variables (such as capital stocks) means that there must be some linkage of the variables' stochastic trends. Such a linkage implies the existence of a cointegrating relation between the variables. This long-term relation is represented by the following equation:

$$GK_t = \theta PK_t^{\beta} \tag{3.2}$$

where PK is the private capital stock
and GK is the public capital stock

In logs, equation (3.2) becomes

$$gk_t = \alpha + \beta pk_t \tag{3.3}$$

where $\alpha = \log \theta$

First, we test for cointegration at the pool level, using the Levin, Lin and Chu test which assumes a common unit root process and the ADF-Fisher Chi Square test which assumes an individual unit root process. Then, we test for cointegration between the private and public capital stocks in each country using Elliott-Rothenberg-Stock and Ng-Perron unit root tests. At the country level, these tests are favoured over the Augmented Dickey Fuller test due to their superior power and size properties.

In order to estimate the cointegrating equations, we employ Stock and Watson's (1993) Dynamic Ordinary Least Squares (DOLS) method. While the least squares method consistently estimates a cointegrating vector, the estimator of β may be substantially biased in small samples and is not efficient. The DOLS method generates an

asymptotically efficient estimator for the cointegrating vector by augmenting the cointegrating equation with leads and lags. The resulting estimator of β is superconsistent, asymptotically normally distributed and efficient. We estimate the cointegrating equation using DOLS (-2,2) as follows:

$$gk = \alpha + \beta pk + \gamma_1 \Delta pk_t + \gamma_2 \Delta pk_{t-1} + \gamma_3 \Delta pk_{t-2} + \gamma_4 \Delta pk_{t+1} + \gamma_5 \Delta pk_{t+2} + \varepsilon_t \qquad (3.4)$$

Cointegration has implications for the short-term behaviour of the public and private capital stocks. If the variables are out of the long-term steady-state relation at a point in time, some mechanism must exist which pushes the variables to their steady-state relation in the long term. When the variables are out of their steady-state relation, an imbalance in the relative capital stocks, that is a deviation from the steady state relation, arises. As Enders (2004) notes, "since the trends of cointegrating variables are linked, the dynamic paths of such variables must bear some relation to the current deviation from the equilibrium relationship." Consequentially, the short-term relation between the private and public capital stocks must include an error-correction mechanism which bridges the long-run equilibrium or steady state implied by cointegration. Where the presence of cointegration cannot be rejected, the short-term relation between the public and private capital stocks is modeled in this chapter by a vector error-correction model as follows:

$$\Delta gk_t = c - \delta_1 (gk_{t-1} - \alpha - \beta pk_{t-1}) + \beta_1 \Delta gk_{t-1} + \beta_2 \Delta pk_{t-1} + \ldots \beta_i \Delta gk_{t-p} + \beta_j \Delta pk_{t-p} + \varepsilon_{1t}$$

$$\Delta pk_t = c + \delta_2 (gk_{t-1} - \alpha - \beta pk_{t-1}) + \gamma_1 \Delta gk_{t-1} + \gamma_2 \Delta pk_{t-1} + \ldots \gamma_i \Delta gk_{t-p} + \gamma_j \Delta pk_{t-p} + \varepsilon_{2t} \qquad (3.5)$$

where gk_t is the public capital stock

pk_t is the private capital stock

p is the number of lagged endogenous terms

and ε_t is a stochastic error term.

The Error-Correction Mechanism (ECM) coefficients given by δ provide a measure of the speed of adjustment towards the long-term equilibrium. Where the annual change in the public capital stock is the dependent variable and assuming that the value of β is positive, the ECM coefficient should be negatively signed if any short-run deviations from the steady-state relation are to be eliminated over the long-run. Equally, the ECM coefficient should be positively signed where the annual change in the private capital

stock is the dependent variable if the elimination of any deviations from the steady-state relation are to be expedited. Of course, momentum in capital stocks which lead to the rapid elimination of any imbalances will not be optimal from an activity viewpoint where that adjustment is in part or in whole effected by a fall in actual investment. Our analysis is particularly interested in the sign and size of the individual estimated ECM coefficients with a view to leading us towards conclusions about the drivers and pace of the adjustment to long-run equilibrium.

Where we fail to establish the existence of a cointegrating relation between the variables of interest, we use a vector autoregression (VAR) model which treats each endogenous variable in the particular model as a function of the lagged values of all endogenous variables within the model as well as exogenous shock variables.

VAR models can be represented as follows:

$$y_t = \alpha_1 y_{t-1} + ... + \alpha_p y_{t-p} + \beta x_t + \varepsilon_t \tag{3.6}$$

where y_t is a vector of endogenous variables
x_t is a vector of exogenous variable
$\alpha_1, ..., \alpha_p$ and β are matrices of coefficients to be estimated
and ε_t is a vector of innovations.

For the purposes of this chapter, for those countries where VAR modeling is used, the real growth rates of private and public investment are the endogenous variables and no exogenous variables are included.

In estimating the speed of adjustment to the long-run equilibrium, we employ a half-life decay formula as follows:

$$t_i = \log(2) / \log(1 + r_i) \tag{3.7}$$

where t_i is the number of years to eliminate half the capital stock imbalance for country *i*
and r_i is the rate of decay, in the case of this chapter, the annual change in the public and private capital stocks expressed as a percentage of the estimated capital stock imbalance for country *i*.

3.5 Empirical Results

3.5.1 Testing for Cointegration

First, tests for the existence of a cointegrated relation between the private and public capital stocks were performed at the pool level. The results are reported in Table 3.1. We cannot reject the hypothesis that a unit root is present in the residuals of the long-term relation (equation 3.2) in our pooled regression for either version of the pooled cointegration test.

Having failed to prove the existence of a cointegrated relation at the pool level, tests for the presence of cointegration between the private and public capital stocks were conducted for each of the twenty countries under consideration. The full results of the Elliott-Rothenberg-Stock and Ng-Perron unit root tests are reported in Table 3.1a. The null hypothesis of no cointegration was rejected in the case of seventeen of the countries examined. In the cases of Finland, Greece and the United States, the null hypothesis could not be rejected at tolerable significance levels.

The results suggest, as expected, that there is a long-term, steady-state relation between the private and public capital stocks in the great majority of developed economies examined. As discussed earlier, this finding has important consequences for the modeling of the short-term dynamics of the private-public capital stock relation. For each of the seventeen countries where a cointegrating relation could not be rejected, we estimated a Vector Error Correction Model (VECM).

Appropriate lag orders for the VAR and VECM analyses were chosen on the basis of a number of selection criteria. Those considered here include the Log Likelihood Ratio (LLR), Final Precision Error information criterion (FPE), the Akaike information criterion (AIC), the Schwarz information criterion (BIC), and the Hannan and Quinn information criterion (HQ). The output of the various information criteria and the selected lag lengths are presented in Appendix 3A.

3.5.2 Estimating Long-Run Relations

Table 3.2 presents the coefficients (α and β) which were estimated using a Dynamic OLS (DOLS) regression. DOLS allows for the long-run relation of the variables to be estimated even where the independent variables are not strictly exogenous. The use of

DOLS generates strict exogeneity by including past and future changes in the independent variables. While the regressions were run primarily to generate estimated coefficients for the long-term relation that in turn would feed into the VECM analysis, the output can provide some insight into the long-run relation of the public and private capital stocks. In neoclassical growth theory, variables such as output and capital grow at the same constant rate in the steady state. However, our empirical evidence offers little support for the view that a unitary long-run relation exists between the public and private capital stocks with the estimated value of β being proximate to 1 only in the case of Greece (1.04) and New Zealand (0.97).

In eleven of the countries considered, the value of β was less than one with particularly small values being reported for the UK (0.33), Denmark (0.34), Ireland (0.55) and the Netherlands (0.59). In these countries, the private sector took a markedly more important role in capital formation relative to the public sector over the period under consideration. In nine countries, the value of β was greater than one with Finland (1.48), Belgium (1.41), Portugal (1.40) and Sweden (1.39) reporting the largest values. For completeness, the countries, including Finland, where the null hypothesis of no cointegration could not be rejected, are included.

3.5.3 Short-Run Dynamics

The VECM output is presented in Tables 3.3, 3.4, 3.5 and 3.6 while the VAR results are presented in Table 3.7. Taking the output of both the VECM and VAR analyses, the results suggest that investment growth of both the public and private varieties is persistent from year to year. In the case of eighteen countries, for both public and private stocks, the immediately prior year's change in the capital stock or investment growth rate is statistically significant and positively signed. In the case of the public capital stock, the exception is Finland while Austria is the exception in the case of the private capital stock. Clearly, last year's investment growth rate is a significant driver of this year's activity according to this output. This is an unsurprising conclusion given the multi-year nature of many capital projects taking the period stretching from planning to delivery.

Taking account of the VECM output, presented in Tables 3.3, 3.4, 3.5 and 3.6 and summarized in Table 3.8, there is solid empirical support for the hypothesis that any disequilibrium between private and public capital stocks is a driver of annual capital stock changes. The error correction element of the VECM output is statistically

significant at the 10% level in sixteen instances across the seventeen countries modeled using the VECM methodology. However, the ECM is considerably more likely to be statistically significant at the 10% level in the case of the public capital stock which accounts for eleven of the sixteen instances. Taking the first piece of substantive evidence, it appears that the process of eliminating deviations from the long-term relation of the capital stocks is more likely to be led by the public sector rather than the private sector.

As noted earlier when outlining the method employed in this analysis, the sign of the ECM coefficient should be negative where the change in the public capital stock is the dependent variable and/or positive where the change in the private capital stock is the dependent variable if imbalances are to be eliminated expeditiously. Further support for the view that the efficacy of the public sector in correcting imbalances is greater is provided by the VECM analysis in the context of the signs of the ECM coefficients. Where the public capital stock is the dependent variable, the ECM coefficient is negatively signed in every instance. As a consequence, we can conclude that the public capital stock responds in a gap-narrowing direction to deviations from the long-term relations of the capital stocks. The evidence where the change in the private capital stock is the dependent variable is rather mixed with a deviation-narrowing positive sign being reported in nine cases while a negatively-signed coefficient is reported in eight countries. However, it is only in two countries (Ireland and UK) that the ECM coefficient where the private sector is the left-hand variable is both negatively signed and statistically significant.

Given the relative statistical significance of the ECM coefficients and prevalence of deviation-narrowing signs reported, the output of our VECM analysis leads us strongly to the view that any deviations from the long-term relation of the capital stocks of a country are more likely to be corrected through public-sector rather than private-sector adjustment.

In the presence of cointegration, a variable is said to be weakly exogenous if it does not respond to the deviation from the long-term equilibrium relation (Enders (2004)). For the purposes of this chapter, we take all instances where the error correction coefficient is statistically insignificant (at levels above 10%) or is zero as indicative of weak exogeneity. Given the relative statistical significance of the ECM coefficients discussed above, we can say that momentum in the private capital stock is more likely to tend towards weak exogeneity. Using the 10% threshold and allowing for countries slightly

above it, the results summarized in Table 3.8 show that public investment is weakly exogenous in four cases (Austria, France, Japan and Norway) while private investment is weakly exogenous in twelve cases (Austria, Denmark, Canada, Australia, Germany, Norway, Sweden, New Zealand, Belgium, France, Italy and the Netherlands). The Japanese result is intuitively appealing given the co-existence in that country of high rates of government investment and depressed economic activity through the 1990s and early 2000s.

Relative capital deficiencies can arise in one of two ways or indeed in a combination of both underinvestment in one stock type and overinvestment in another. A negative ECM coefficient where the change in the public capital stock is the left-hand variable and a positive ECM coefficient where the change in the private capital stock is the left-hand variable are two sides of the same coin in terms of accommodating an expeditious adjustment. The period of time needed to correct the deviation from the long-term relation is obviously hastened if both government and private capital are simultaneously adjusting in the appropriate direction. Indeed, our results suggest that such a two-handed approach to correcting a deviation is somewhat short of universal with suitably–signed, countervailing ECM coefficients reported in the cases of nine of the seventeen countries considered. Countries experiencing double-edged convergence are Canada, Germany, Norway, Sweden, Japan, Portugal, France, Italy and Spain.

Moreover, in the case of all the other countries considered, with one notable exception, the inappropriately signed ECM coefficient where private investment is the left-handed variable is not of sufficient size to outweigh the public sector's imbalance-correcting adjustment although it does prolong the adjustment process.

The exception is Ireland where the deviation-expanding ECM coefficient (where the change in the private capital stock is the left-hand variable (-0.124)) is larger than the deviation-narrowing ECM coefficient (where the change in the public capital stock is the left-hand variable (-0.079)). Were overall capital momentum influenced solely by the presence of a relative deviation in the long-term relationship and were such coefficients to exist indefinitely, Ireland would experience public sector investment growth attempting and failing to catch up with buoyant private capital formation. This finding runs counter to the results of the cointegration tests discussed earlier. As shown in Table 1, the evidence is strong that the capital stocks are cointegrated in the case of Ireland with the null hypothesis of no cointegration being rejected at the 1% level using both the Elliott-Rothenberg-Stock and Ng-Perron Unit Root Tests. The peculiar result

for Ireland encouraged us to consider alternative lag lengths in the VECM analysis. However, in the alternative VECM analysis, presented in Table 3.6, the private capital stock's ECM coefficient continues to be negatively signed. This result for the period under study is not necessarily counter-intuitive given the pace of Irish economic growth since the early 1990s, the need for substantial growth by both public and private capital stocks to catch up with rapid growth in current activity, the role of private sector investment in that expansion, the emergence of boom-like conditions in real estate and a relatively late response of government investment to private sector capital activity. However, it should be noted that our sample period ends in 2003. Since then, the Irish Government has introduced multi-annual resource envelopes for all investment areas and, in its latest National Development Plan, has allocated more than 5% of GNP to Exchequer-funded capital investment over the period 2007-2013.

The overall speed of adjustment to a deviation from the long-term relation of the capital stocks is affected by factors other than the ECM coefficient. The actual speed of adjustment is given by the total annual change in the capital stock type divided by the size of the relative imbalance at a point in time. The relative capital stock imbalances were calculated for the VECM countries using the α and β values generated earlier by Dynamic Ordinary Least Squares and the long-term relation presented in Equation 3.2. The estimated mean relative capital stock imbalances expressed as a percentage of the total capital stock are summarized in Table 3.9 and presented graphically in Charts 3.2a to 3.2s. Imbalances arising due to a relative inadequacy of the public capital stock are signed negatively while those arising due to a relative inadequacy of the private capital stock are signed positively. Short-term imbalances which are due to relatively inadequate public capital stocks are reported on average in ten (and in 2003 in twelve) of the seventeen countries considered. Estimated imbalances arise on foot of a relatively inadequate private capital stock on average in seven countries, (Australia, Austria, Canada, France, Japan, Norway and Spain), although this number falls to five by 2003 (Australia, Canada, France, Norway and Spain), the last period considered.

Given the estimated deviation findings, we can conclude that capital imbalances are more likely to arise due to a relative deficiency in the public capital stock. Therefore, in the majority of countries, the adjustment to the long-run steady state will involve positive public investment momentum and negative private investment momentum if the adjustment process is to be most expeditious or the former momentum only if that process is not to have a dampening effect on activity. Taking the estimated deviation outturn together with the findings of our ECM analysis that public capital stocks are

more responsive to relative imbalances and that private capital stocks tend towards weak exogeneity, we can see that the attempted adjustment to the long-run steady state is effected through positive growth in public investment in the majority of countries.

The average magnitude of the estimated deviations is small in terms of the total capital stock with the notable exception of Belgium, Germany and New Zealand. However, given the relative size of the public and private capital stocks highlighted in Chart series 3.1, the number of countries in which the public capital stock is relatively deficient, and the relative responsiveness of the capital stock types, such imbalances may not be readily eliminated. In order to bring a time dimension to the speed of convergence issue, we use the results of a half-life decay analysis, presented in Table 3.10.

The ECM coefficients, summarized in Table 3.8, measure the responsiveness of capital investment to any capital imbalances. However, the overall speed of adjustment is determined by the total annual change in the capital stock divided by the estimated capital imbalance. The speed of adjustment in years was calculated using a half-life decay formula and the results for each country and for private, public and total convergence speeds are laid out in Table 3.10. The results suggest that convergence to the long-run steady state is possible only in the case of seven countries on average (or five countries taking the 2003 outturns), that is those countries with positively signed convergence speeds. These countries are also countries with private capital stocks that are low relative to their government capital stock. For all other countries, that is those countries whose public capital stocks are low relative to their private capital stocks, the relative size of the capital stocks makes it challenging for public investment to eliminate the imbalance in the absence of a sustained fall in private capital investment despite the presence of convergent momentum in public capital in each country.

3.5.4 Impulse Response Functions

Impulse response functions were also calculated for each country using JMulti software[7]. For the seventeen countries where the null hypothesis of no cointegration could not be rejected, the impulse response functions arising from VECMs were calculated and are presented graphically in Chart series 3.3. For Finland, Greece and the USA, a series of simple impulse response functions were run with the logged changes in the private and public capital stocks providing the endogenous variables.

[7] JMulti (www.jmulti.de) is a free interactive software package designed for time series analysis. The project is supported by the German Research Foundation.

The impulse response functions are presented graphically in Charts 3.3aa to 3.3tb. Each chart presents a point estimate of the impulse responses together with bootstrapped 90% confidence intervals on a 30 year horizon. The bootstrapping process employed took the following steps: Firstly, the parameters of the model were estimated. Centred residuals were calculated using the estimated residuals. Then the bootstrap residuals were generated by randomly drawing with replacement from the set of centred residuals. These outputs were then used to construct the bootstrap time series recursively. The model was then re-estimated and the impulse response functions calculated. These steps were repeated 100 times to generate bootstrap distributions from which 90% confidence intervals were constructed.

The results of the impulse response functions present further evidence on the relative responsiveness of public and private capital investment. In general, the response of public investment to an innovation in private investment is both positive and statistically significant with such outturns being reported, at least at some point in the response horizon, in sixteen of the twenty cases considered. In the remaining four cases, namely, Austria, France, Japan and Norway, the responses are statistically insignificant by reference to the 90% confidence intervals. The largest statistically-significant responses of public investment to an innovation in private investment are recorded in Belgium, Italy, Spain and Sweden while the impact is sustained and positive in Australia, Belgium, Canada, Finland, Italy, the Netherlands, New Zealand, Portugal, Spain and Sweden over the 30 year horizon. Ireland is noteworthy as the only country where a strongly positive and significant impulse response of public investment to private investment in the first half of the horizon period, becomes negative and significant in its later years.

In contrast, the responses of private investment to an innovation in public investment are mixed. Here, in ten of the twenty instances, the responses of private investment are statistically insignificant taking account of the 90% confidence intervals. Of the remaining countries, five show positive responses, four show negative responses while Canada reports initial negative and medium-term positive responses. It appears that public investment had a crowding-out impact on private investment in a limited number of countries sampled, namely Belgium, Canada (initially), Ireland, New Zealand and the UK. It is only in the case of Canada, that we find evidence supportive of the view, outlined in the literature review, that there are two opposing forces influencing the response of private capital to an increase in public capital.

The positive nature of the public investment impulse responses adds support to the view that public investment reacts to momentum in private investment. The relative strength and sign of the impulse response functions is consistent with evidence presented in this chapter that public investment responds more readily to private investment developments than vice versa. This conclusion dovetails with the results of the ECM analysis, and the estimation of relative capital imbalances.

3.6 Conclusion

The evidence presented in this chapter suggests that there is a long-term steady-state relation between the public and private capital stocks in the great majority of developed countries considered. However, the magnitude of any short-run deviation from the steady state is not the primary driver of investment activity. Rather, one year's investment outturn is strongly and positively related to the previous year's outturn in nineteen of the twenty cases analysed. In the very short-term at least, a prior year's performance is an important determinant of a current year's outturn for both public and private investment.

This chapter also presents solid empirical support for the hypothesis that any existing deviation of the private and public capital stocks from their steady-state relation is a driver of annual stock changes. Moreover, the output of our VECM analysis reveals that any such deviations are more likely to be corrected through public-sector rather than private-sector adjustment. The chapter's estimated deviation findings allow us to conclude that capital imbalances are more likely to arise due to a relative deficiency in the public capital stock. Therefore, in the majority of countries, the adjustment to the long-run steady atate will involve positive public investment momentum and negative private investment momentum if the adjustment process is to be most expeditious or the former momentum only if that process is not to have a restraining effect on activity.

Taking our findings in their totality, we can conclude that the most potent short-term relation between the capital stocks involves public sector investment responding to private sector investment activity. Rather than public investment exerting a universally crowding-out or crowding-in influence on private investment, the evidence presented in this paper suggests that public investment is most likely to be enticed by activity in private investment.

For the majority of countries considered, the relative size of the capital stocks makes it challenging for public investment to eliminate the imbalance in the absence of a sustained fall in private capital investment despite the presence of convergent momentum in public capital in each country. Given the long-term steady-state relations presented here, we expect to see either a marked increase in government investment spending and/or a sustained decline in the private capital stock over the years ahead.

Appendix 3.A Estimation of Lag Lengths

	LLR	FPE	AIC	BIC	HQ	Selected
USA	3	3	4	3	3	3
UK	3	3	3	3	3	3
Austria	2	2	2	2	2	2
Belgium	4	4	4	2	2	4
Denmark	2	2	2	2	2	2
France	3	4	4	3	4	4
Germany	2	3	3	2	3	3
Italy	4	4	4	2	4	4
Netherlands	2	4	4	2	4	4
Norway	3	3	3	2	3	3
Sweden	3	3	3	3	3	3
Canada	2	2	2	2	2	2
Japan	3	3	3	3	3	3
Finland	3	4	4	3	3	3
Greece	2	3	3	2	2	2
Ireland	3	4	4	2	4	4
Portugal	3	3	3	3	3	3
Spain	4	4	4	2	4	4
Australia	2	3	3	2	2	2
New Zealand	3	3	3	3	3	3

Notes: *The following lag selection criteria were examined: Log Likelihood Ratio (LLR), Final Prediciton Error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (BIC) and the Hannan-Quinn information criterion (HQ).*

Chart 3.1aa - Australia

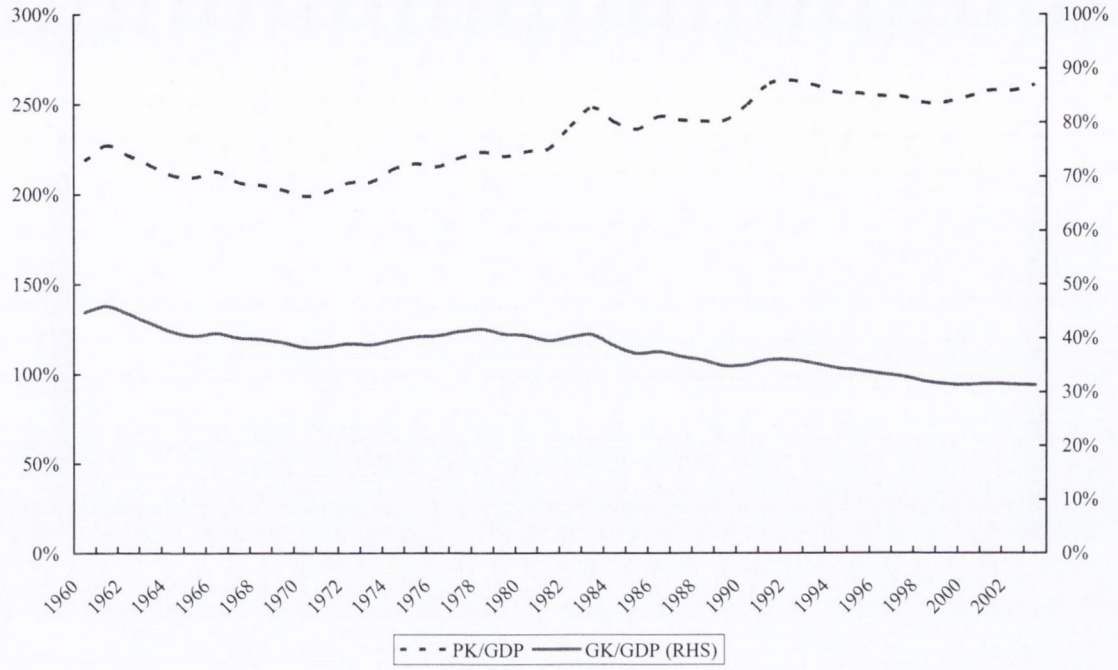


Chart 3.1ab - Australia

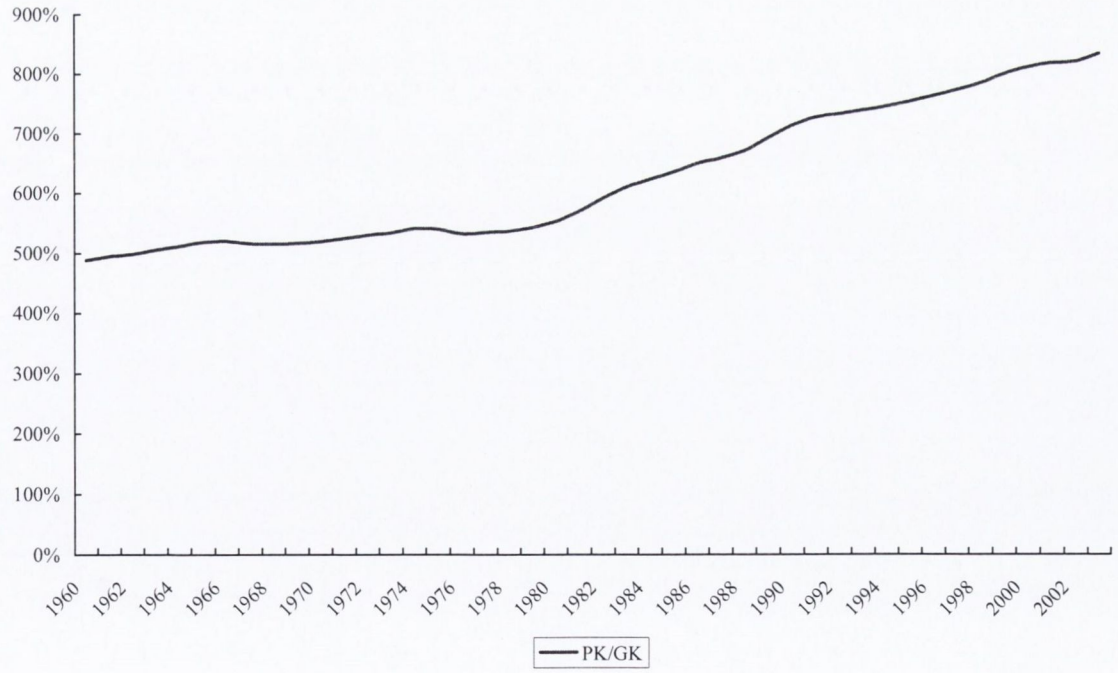


Chart 3.1ba - Austria

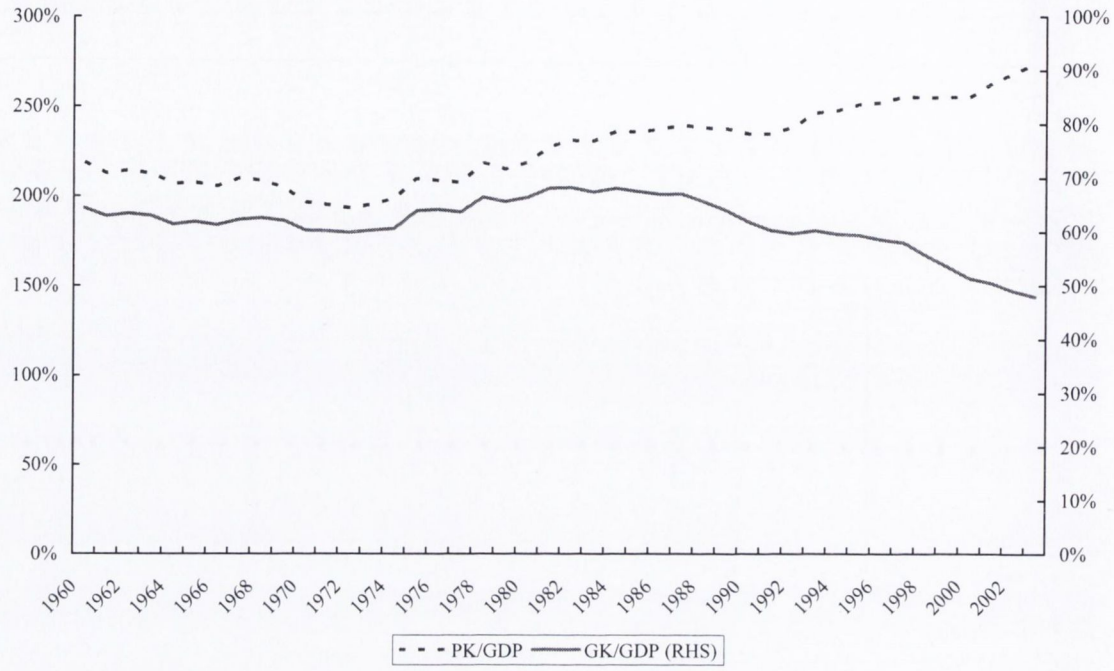


Chart 3.1bb - Austria

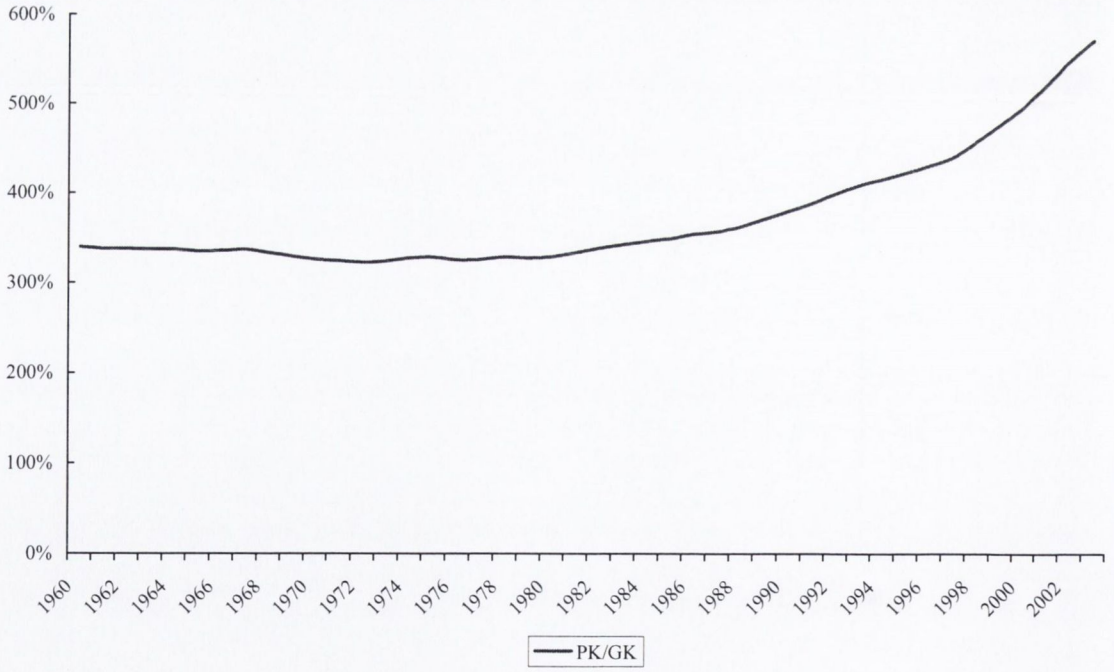


Chart 3.1ca - Belgium

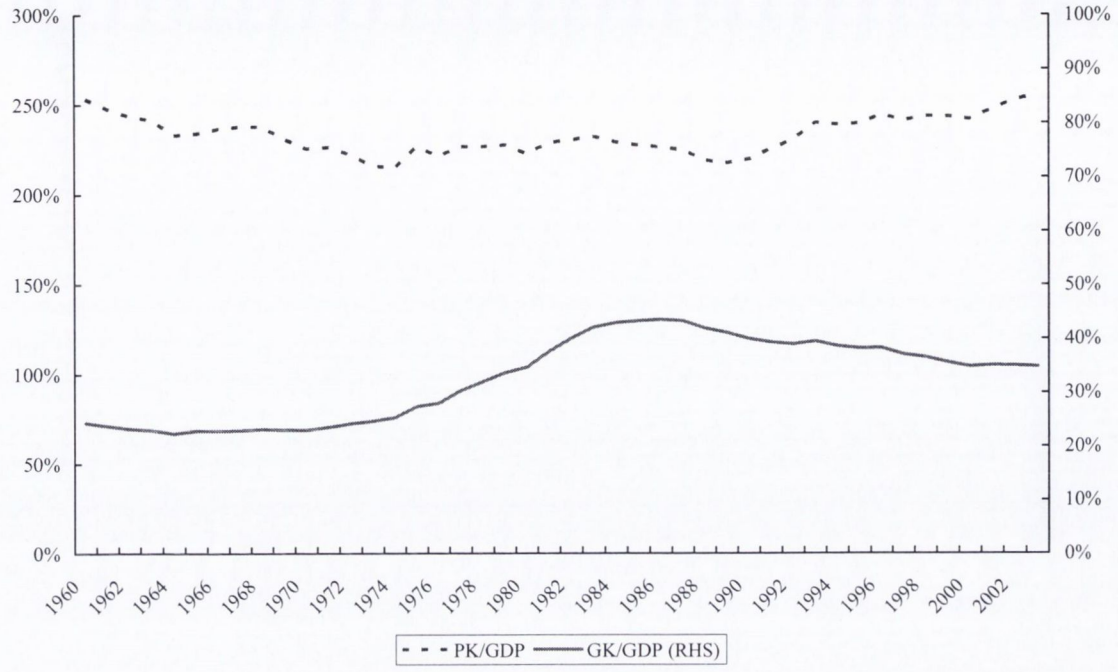


Chart 3.1cb - Belgium



Chart 3.1da - Canada

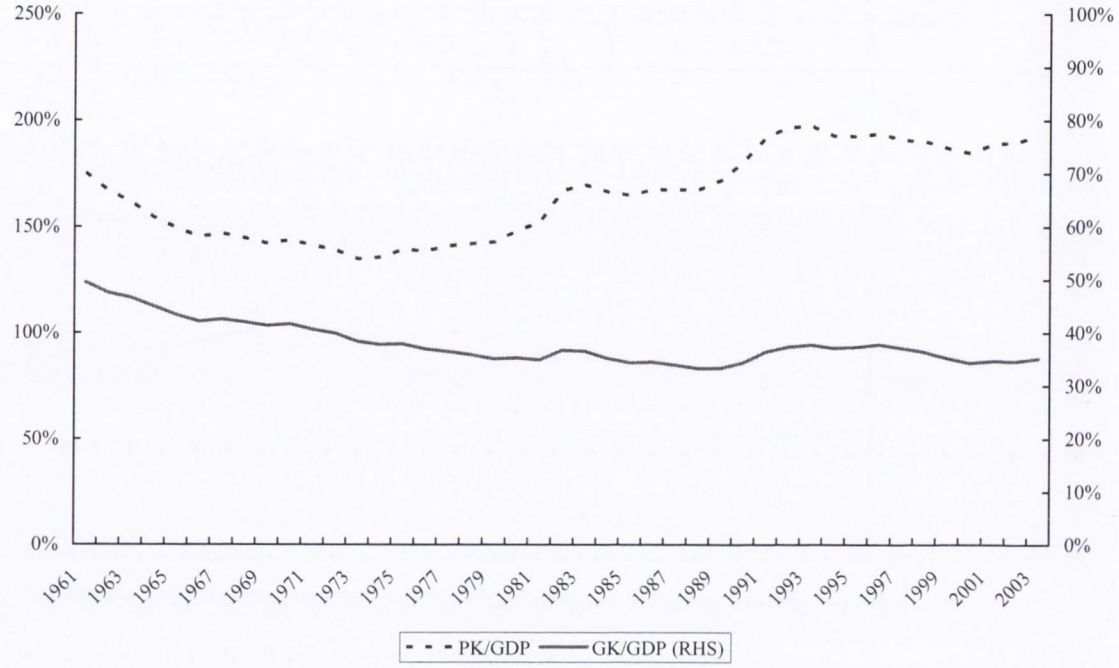


Chart 3.1db - Canada

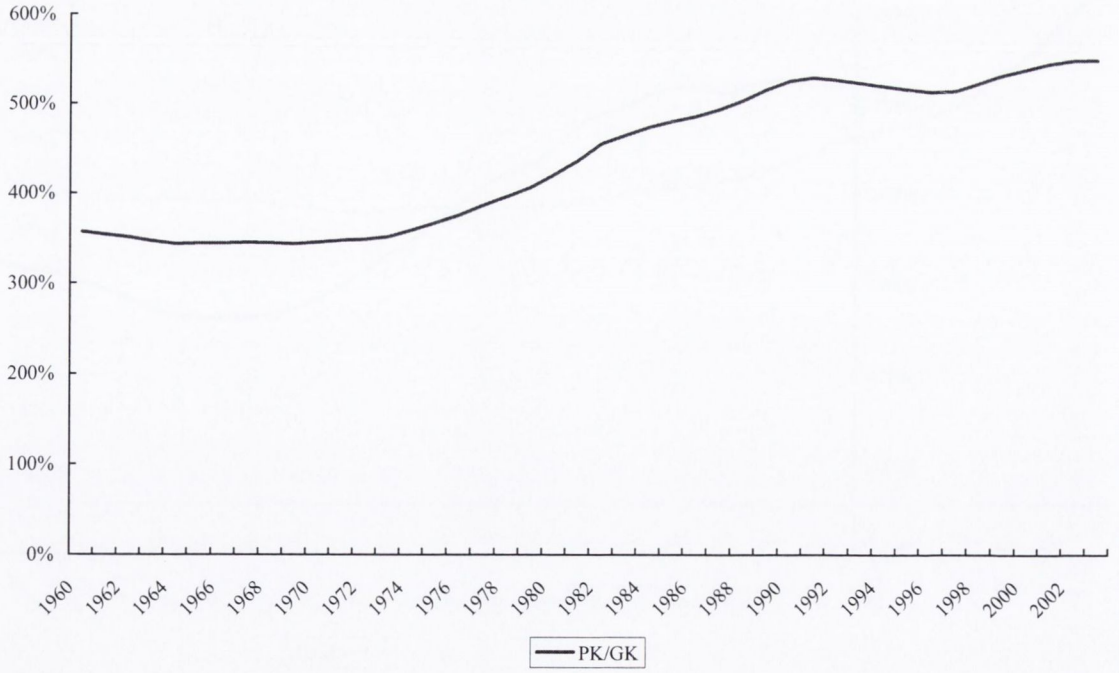


Chart 3.1ea - Denmark

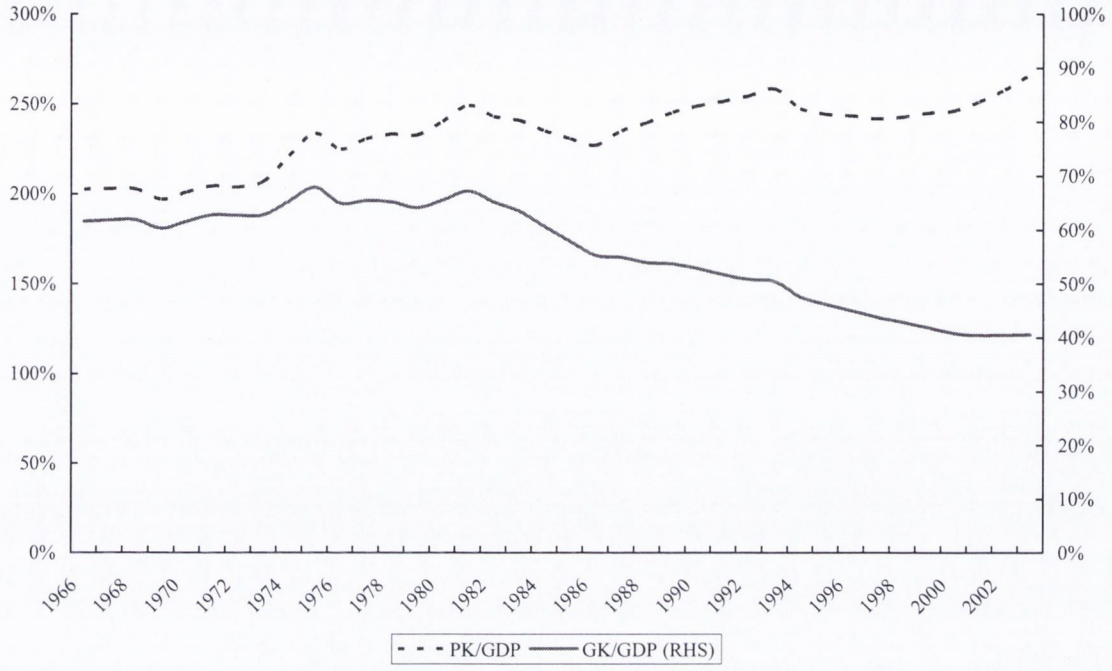


Chart 3.1eb - Denmark

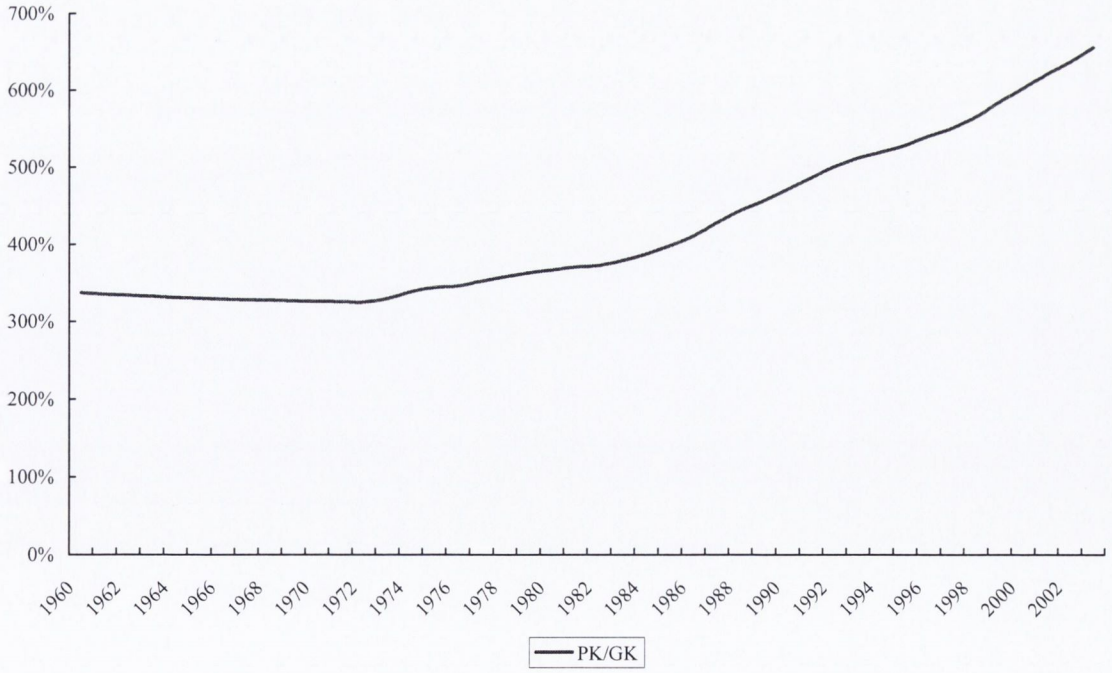


Chart 3.1fa - Finland

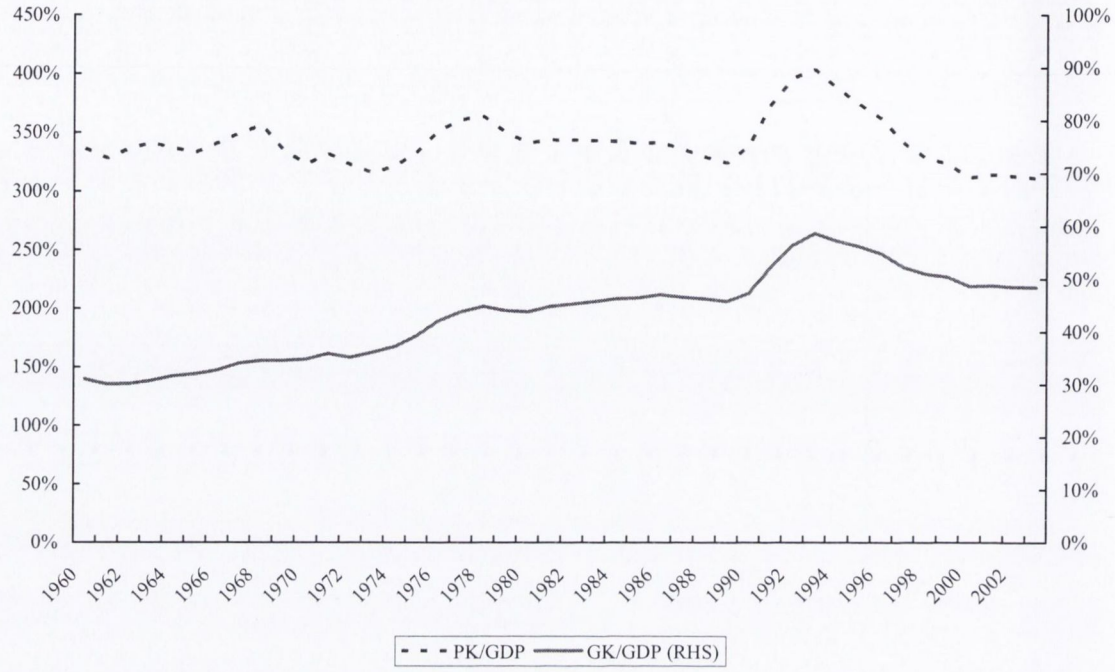


Chart 3.1fb - Finland

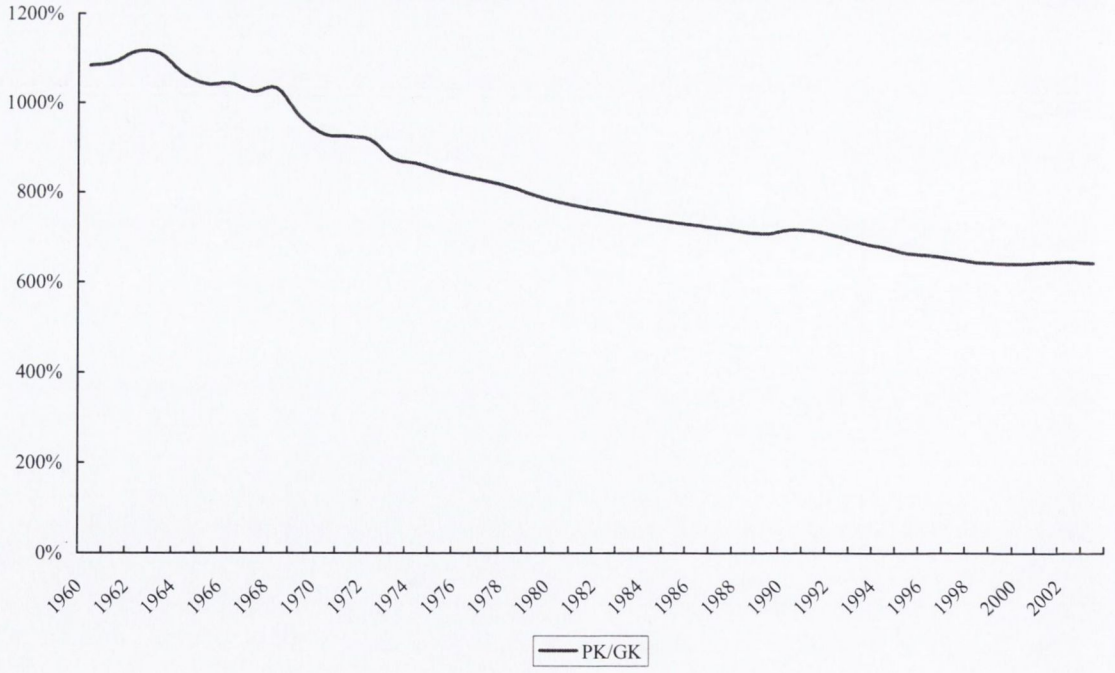


Chart 3.1ga - France

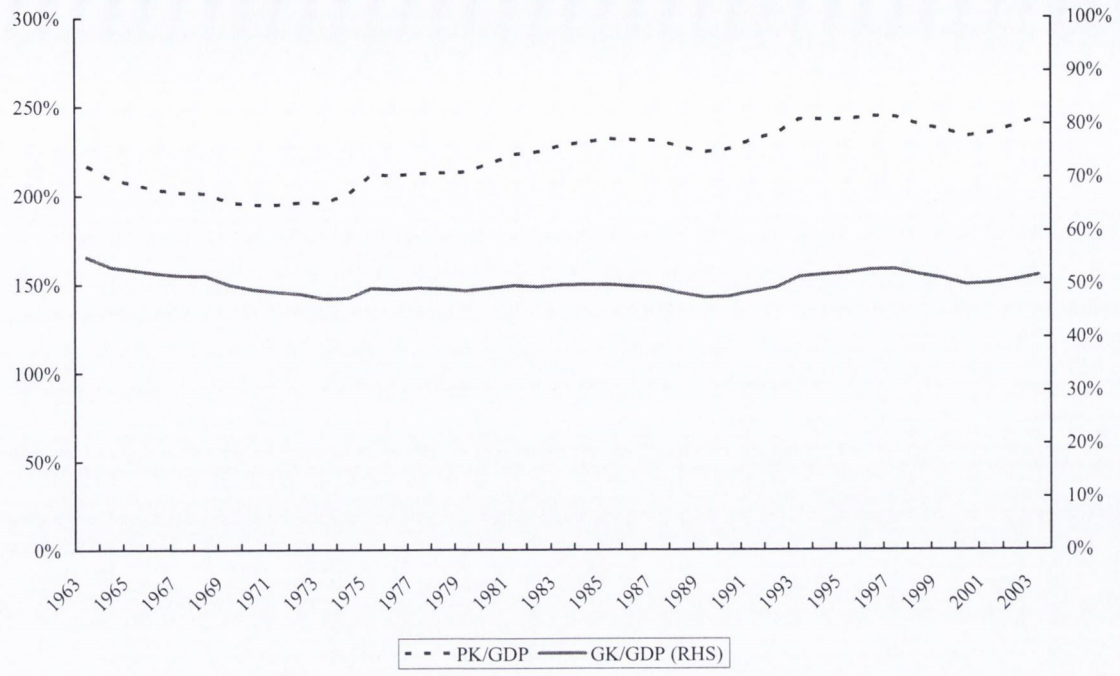


Chart 3.1gb - France

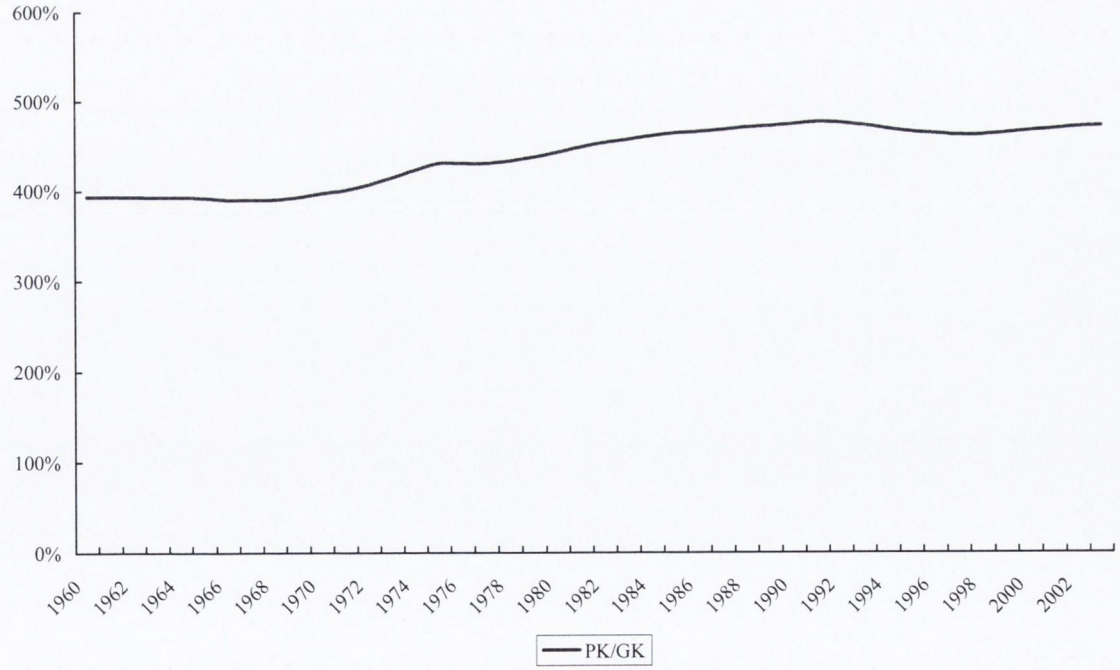


Chart 3.1ha - Germany

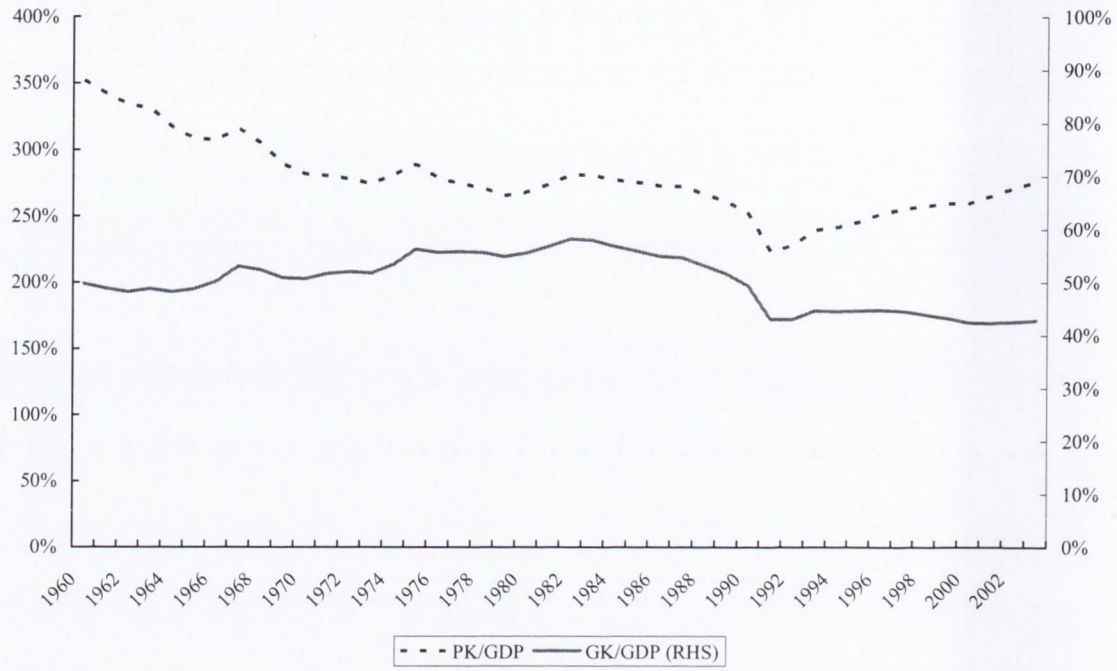


Chart 3.1hb - Germany

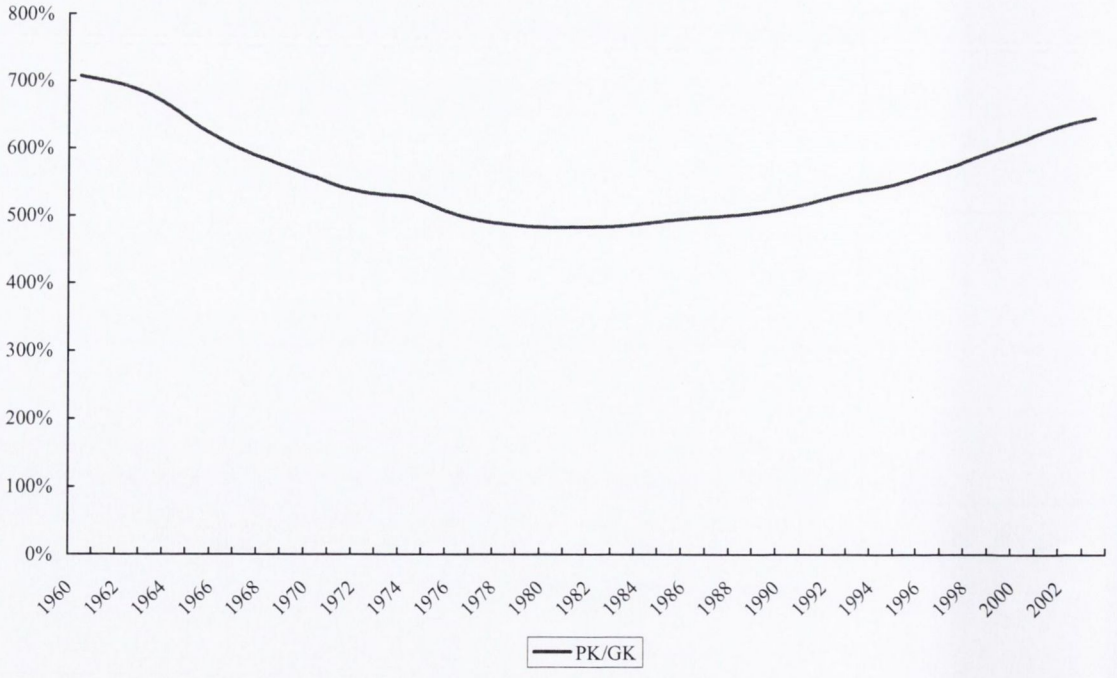


Chart 3.1ia - Greece

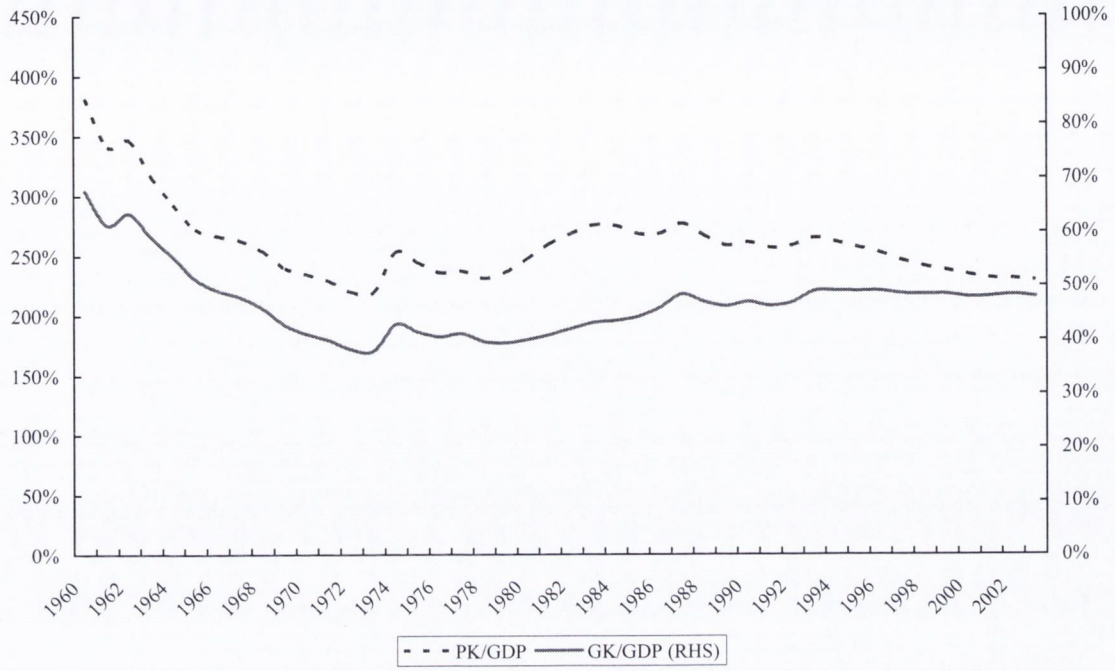


Chart 3.1ib - Greece



Chart 3.1ja - Ireland

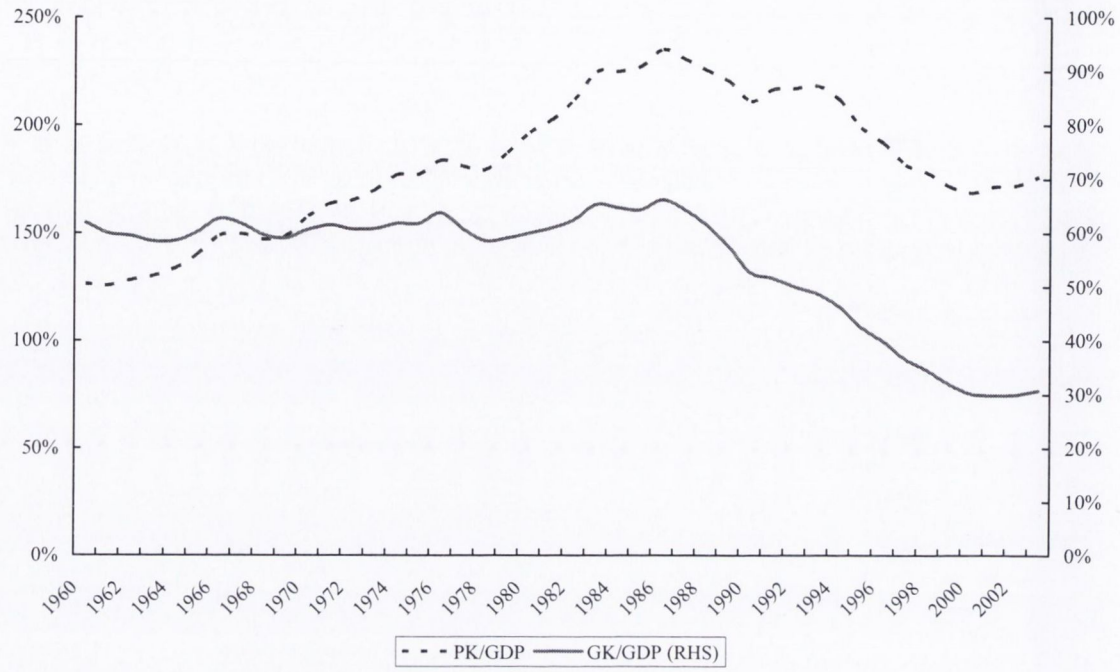


Chart 3.1jb - Ireland

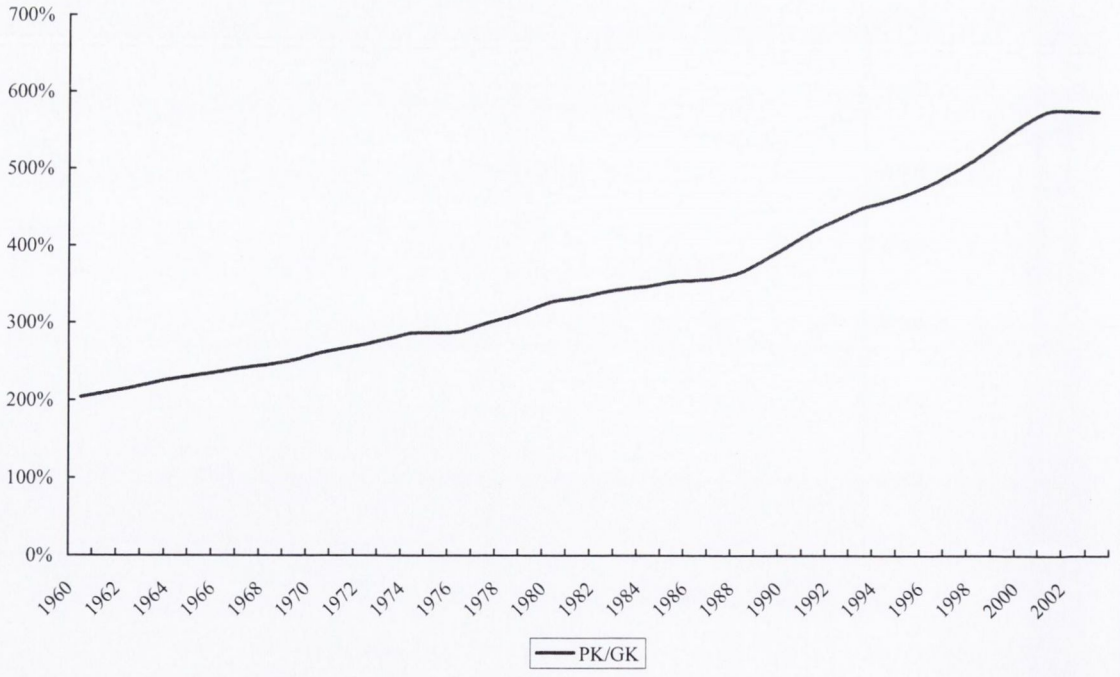


Chart 3.1ka - Italy

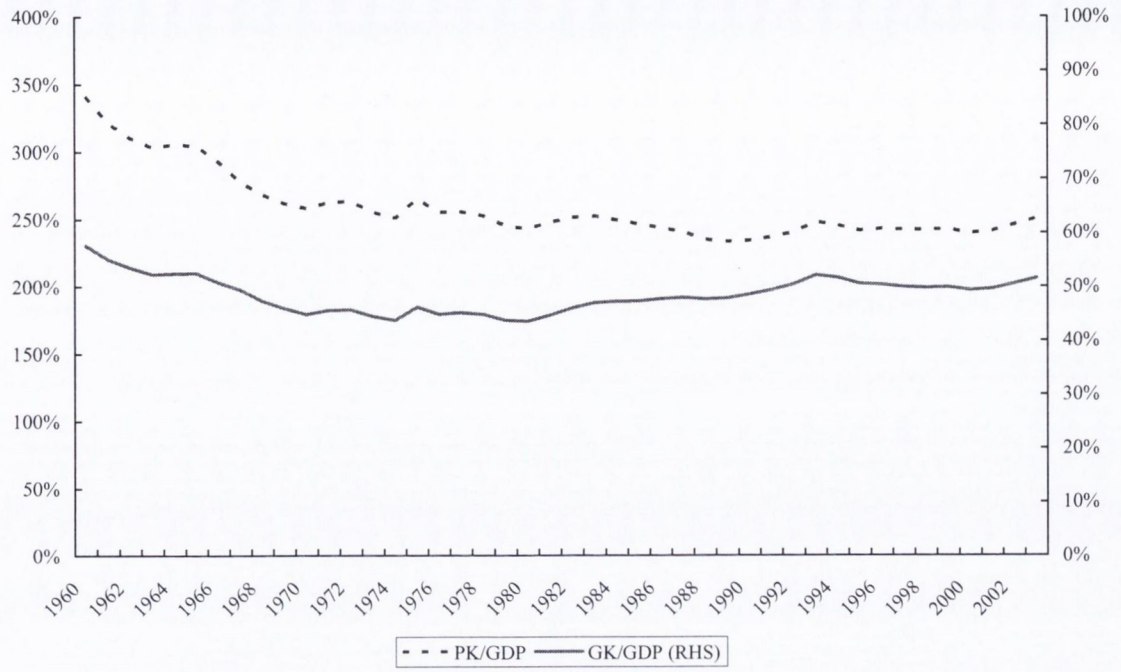


Chart 3.1kb - Italy

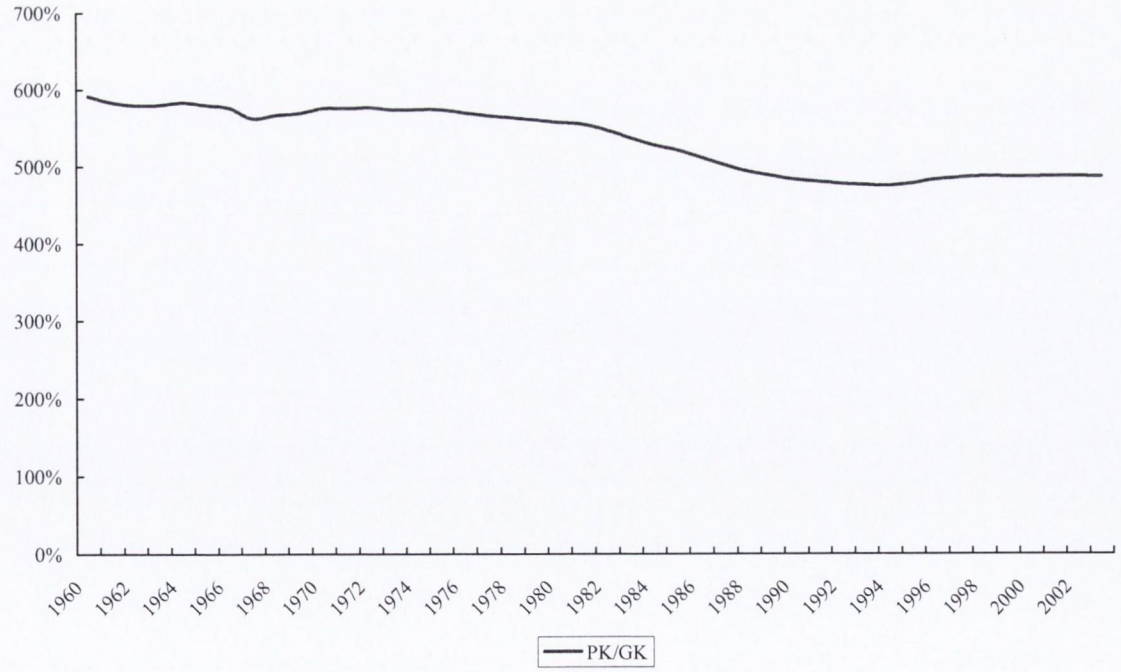


Chart 3.1la - Japan

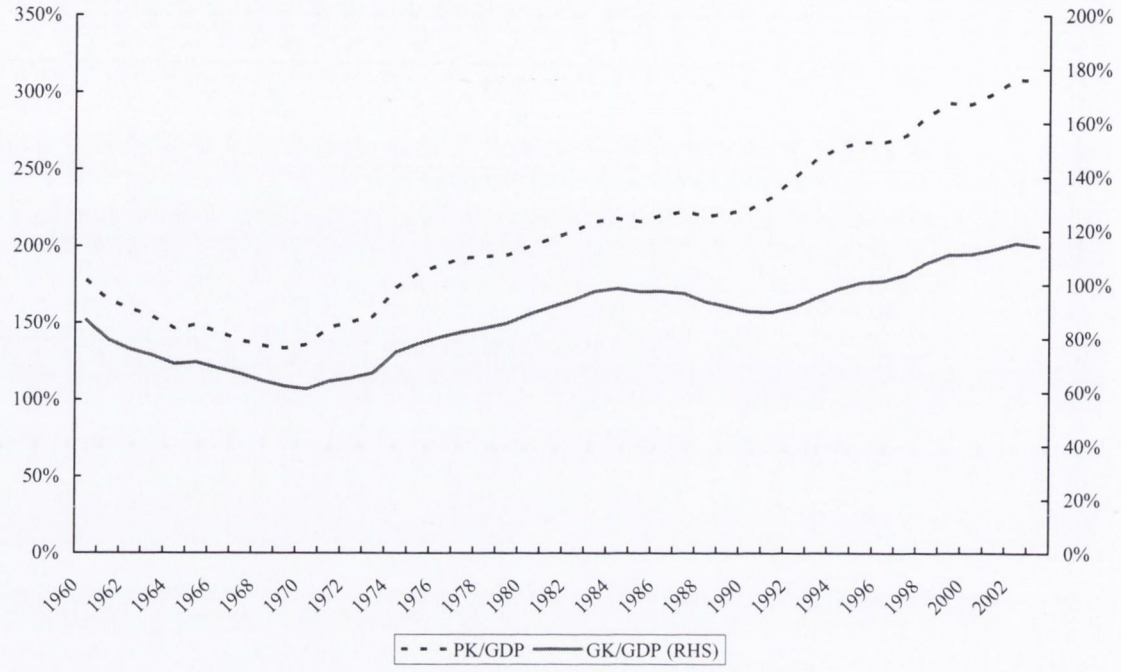


Chart 3.1lb - Japan

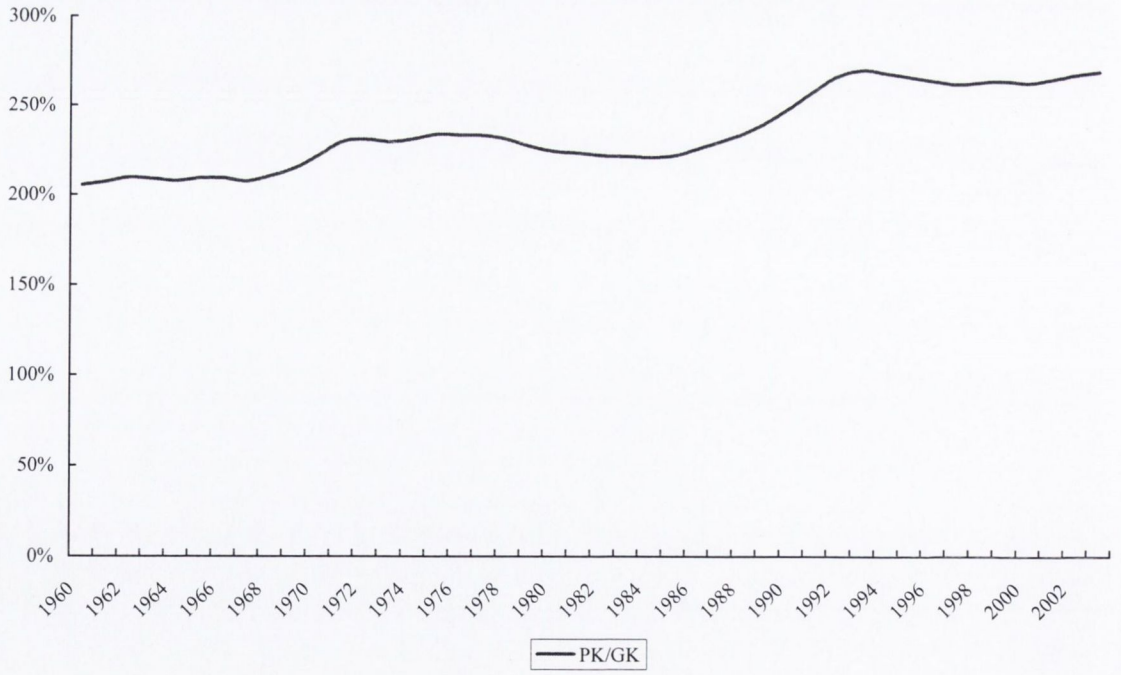


Chart 3.1ma - Netherlands

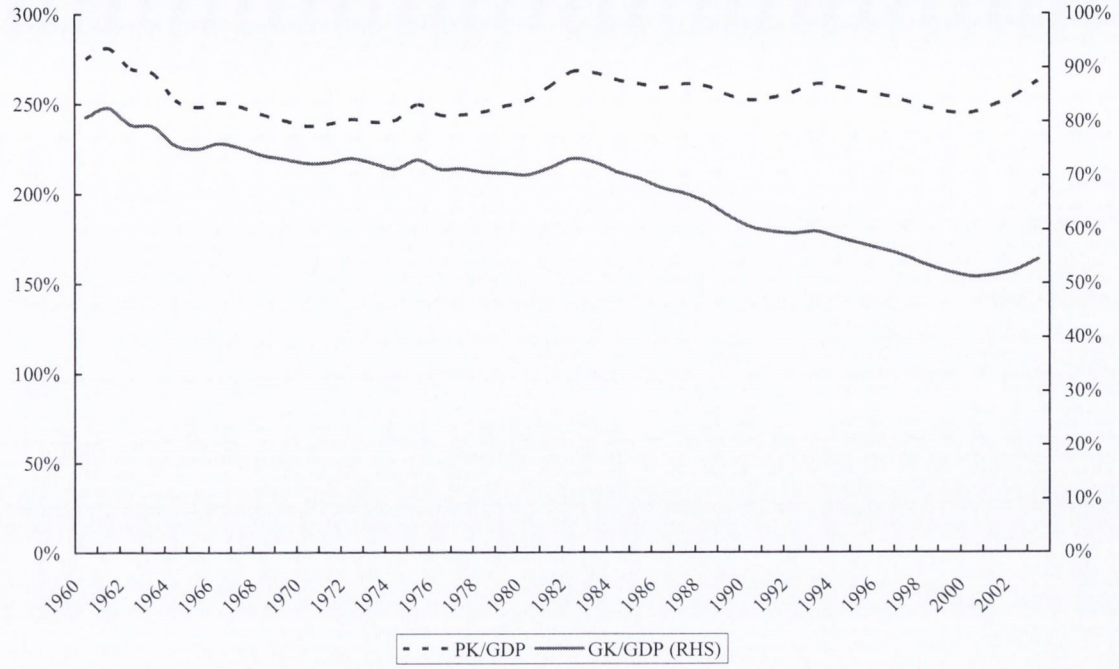


Chart 3.1mb - Netherlands

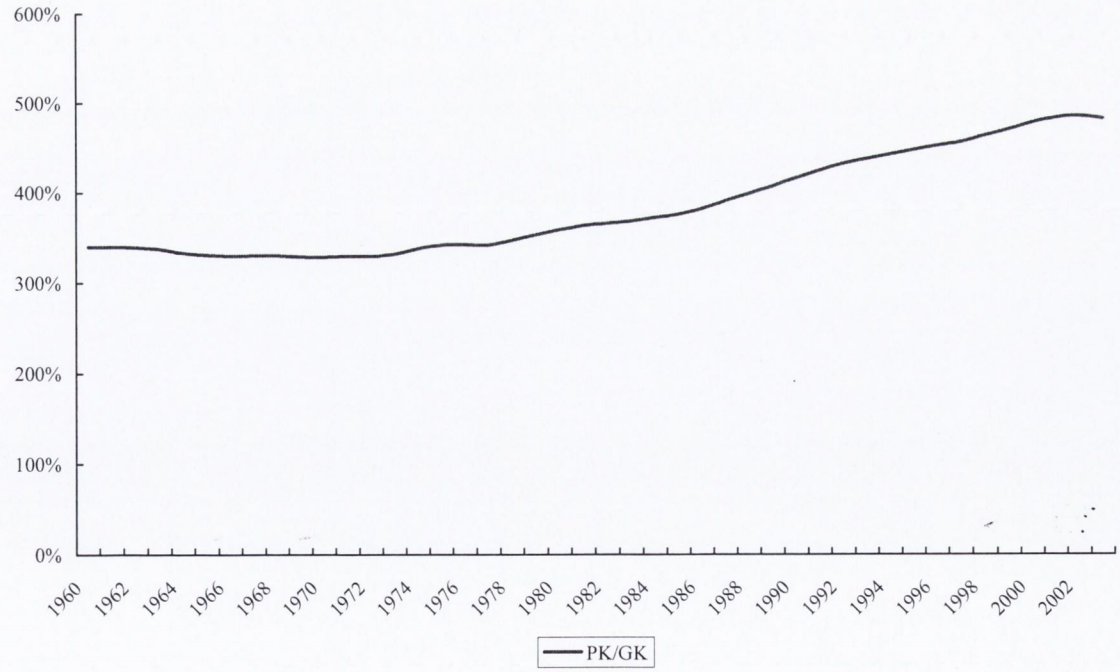


Chart 3.1na - New Zealand

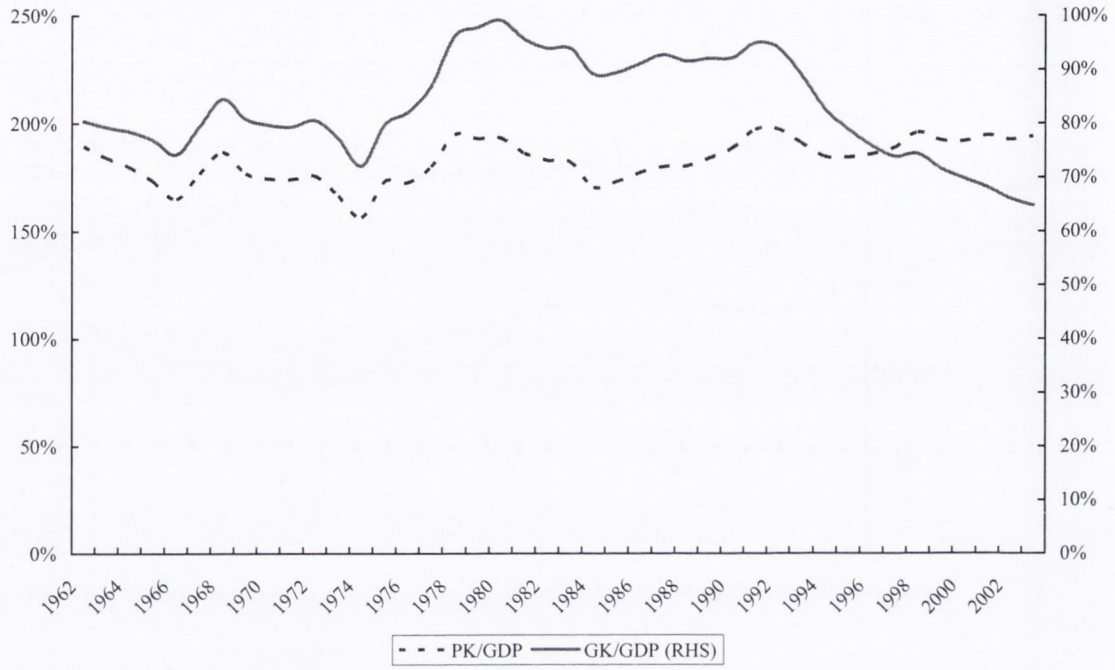


Chart 3.1nb - New Zealand

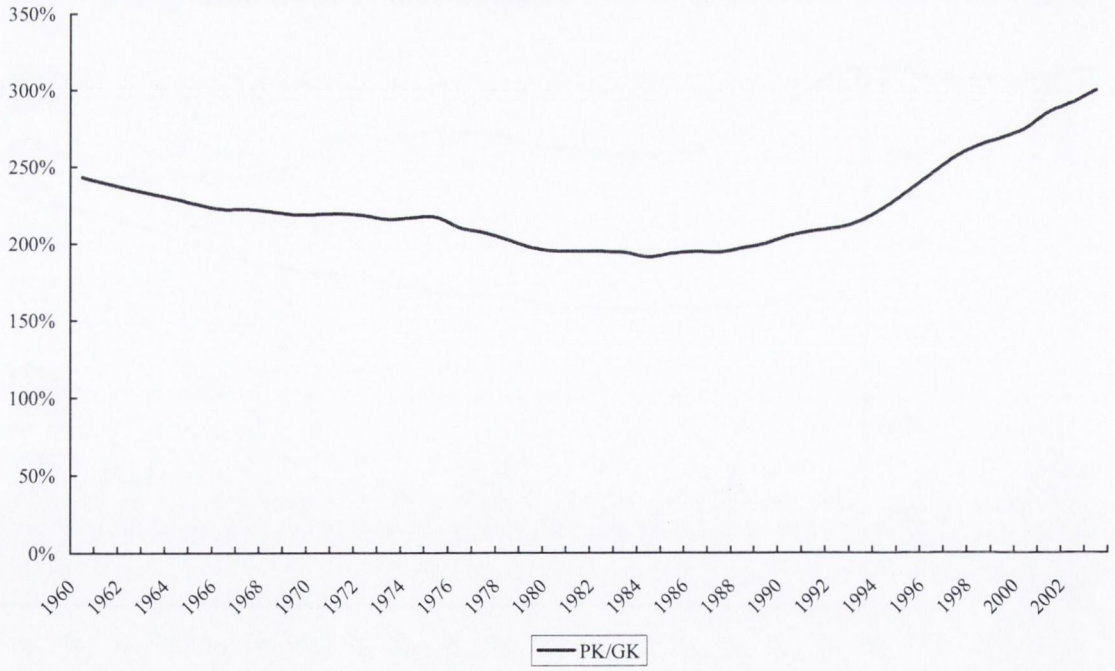


Chart 3.1oa - Norway

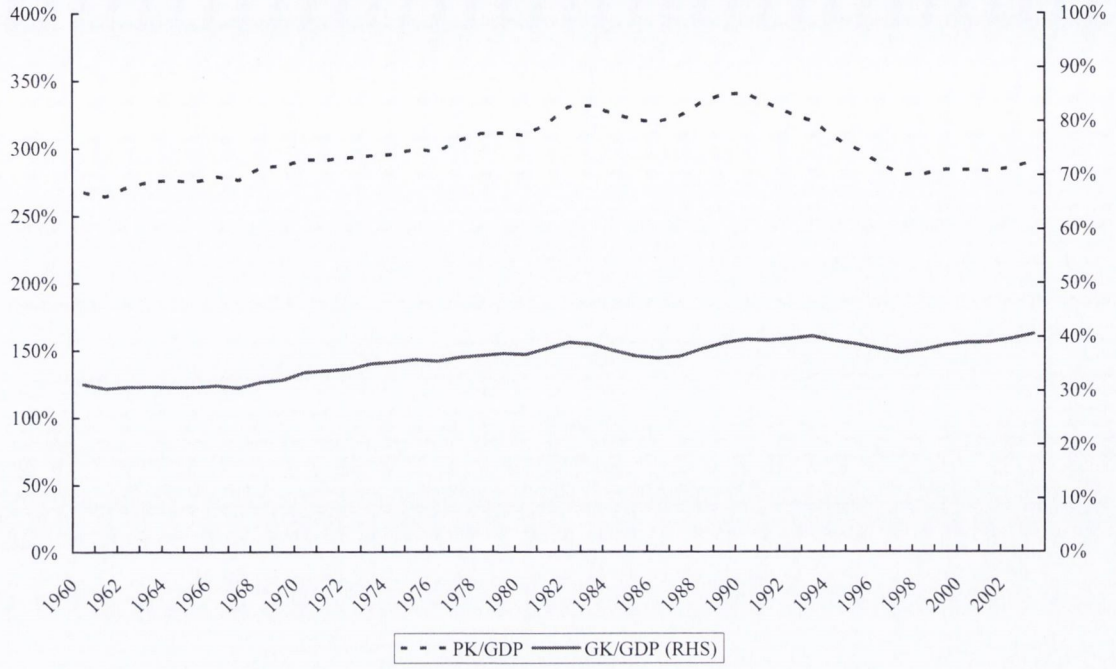


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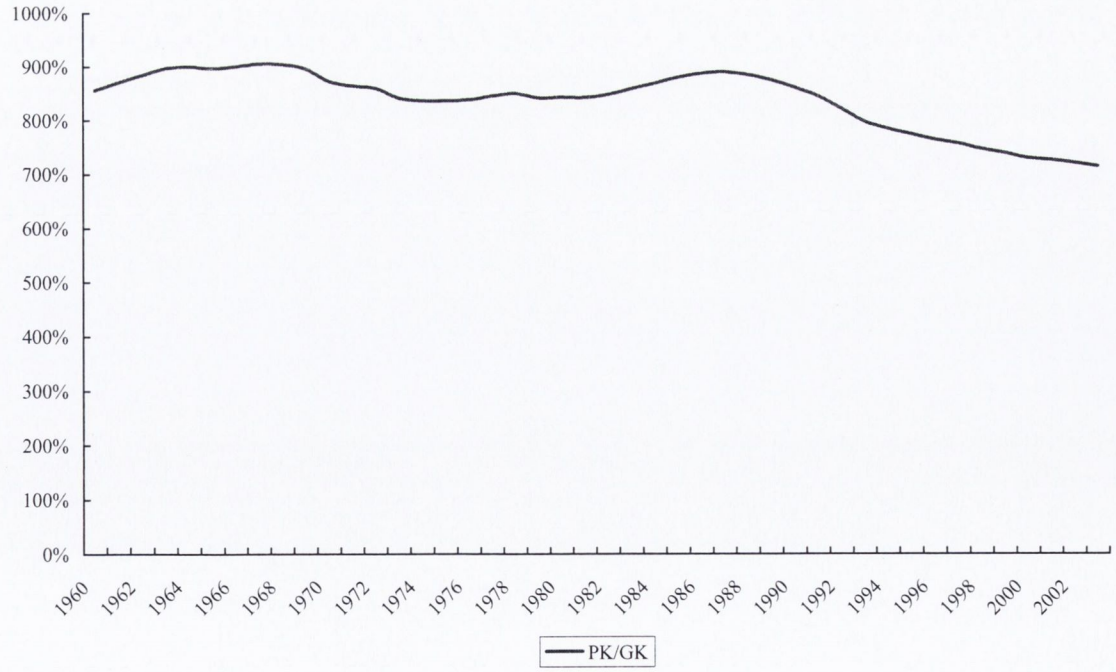


Chart 3.1pa - Portugal

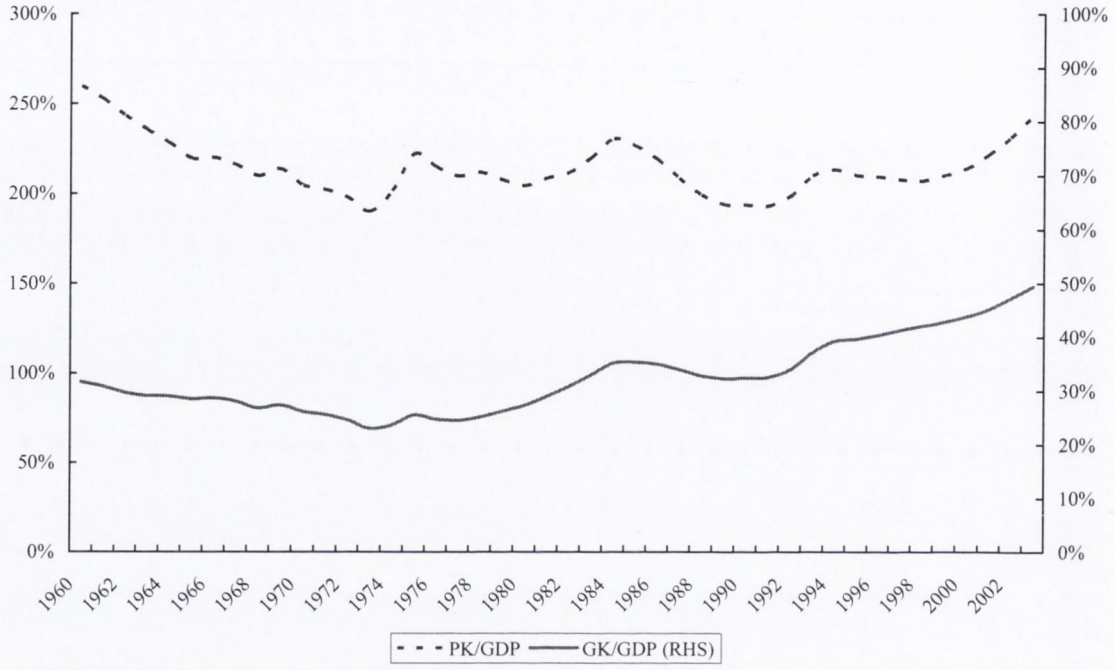


Chart 3.1pb - Portugal

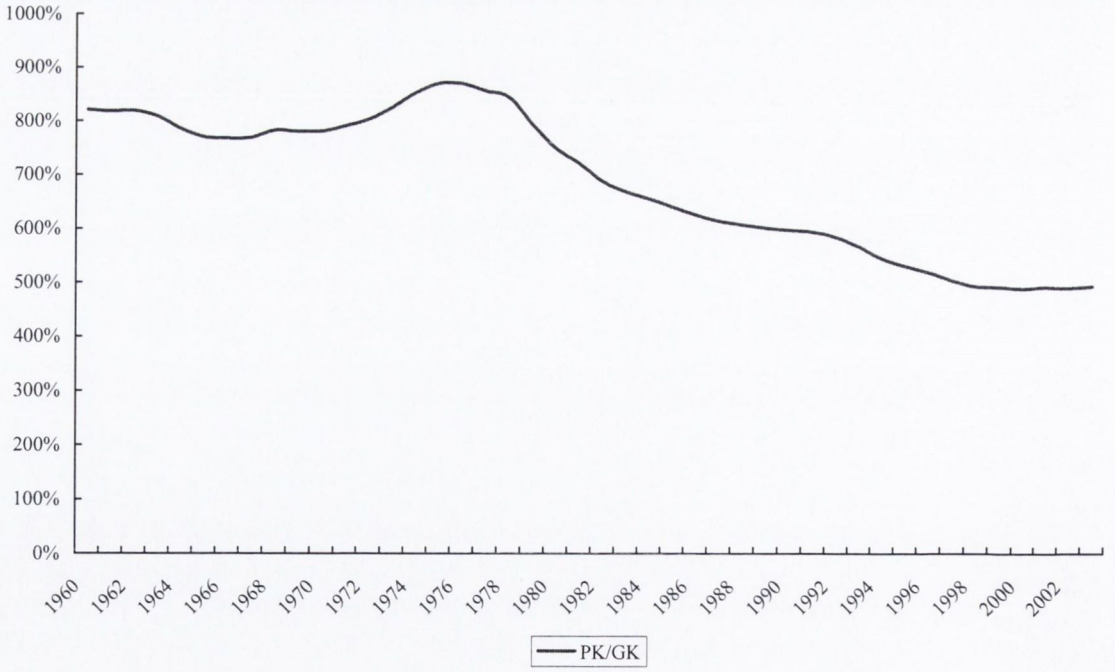


Chart 3.1qa - Spain

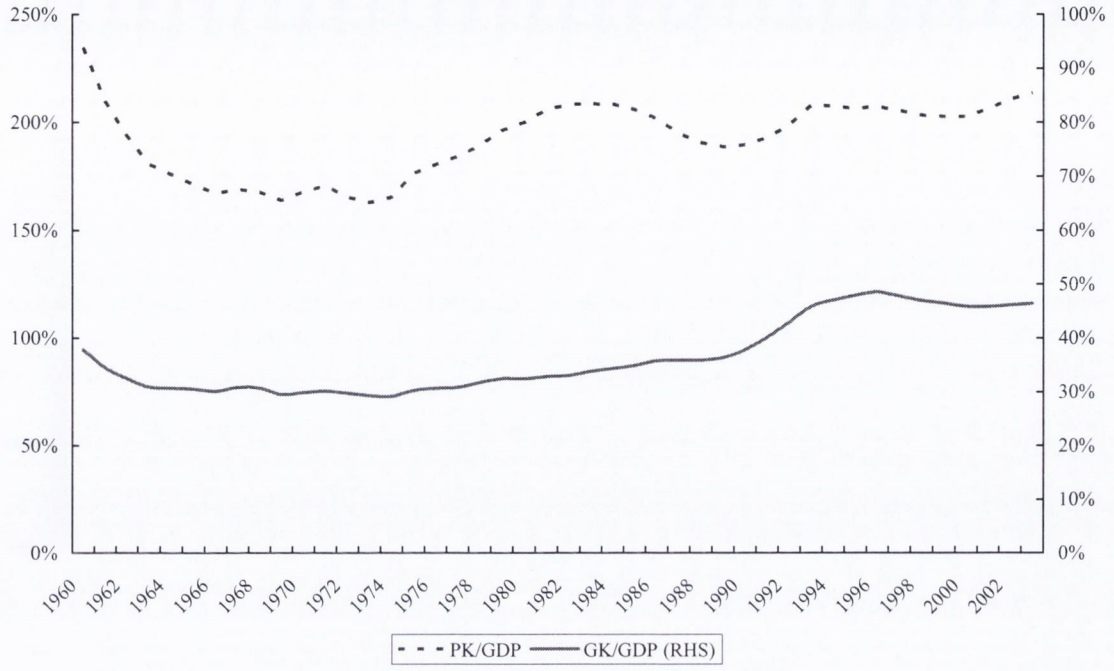


Chart 3.1qb - Spain

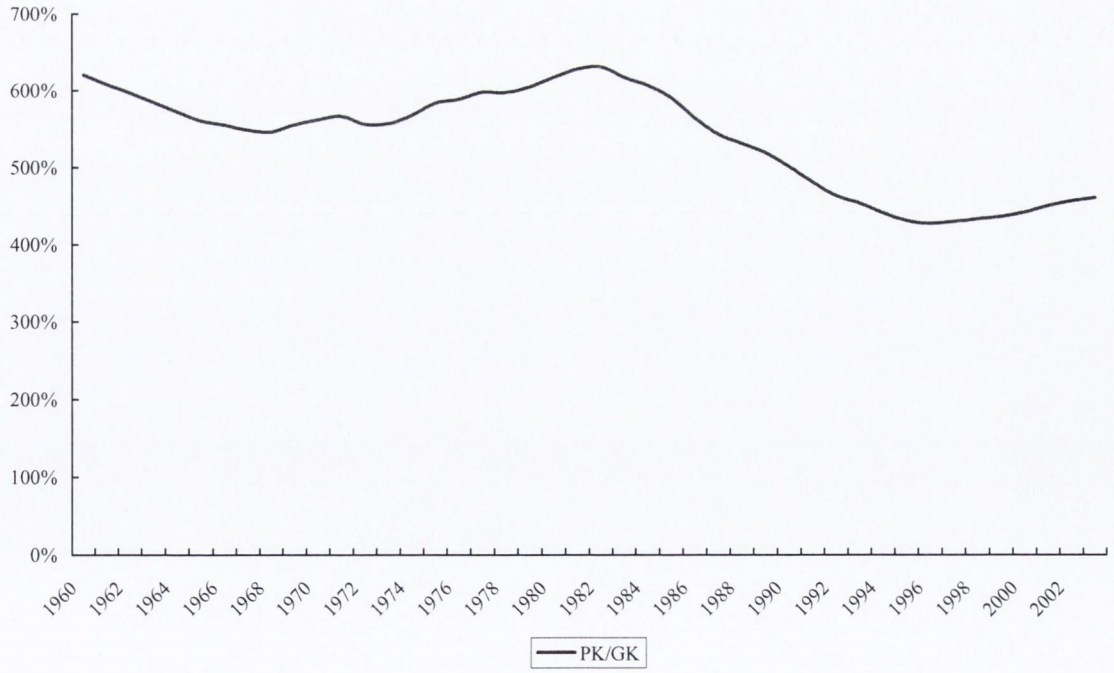


Chart 3.1ra - Sweden

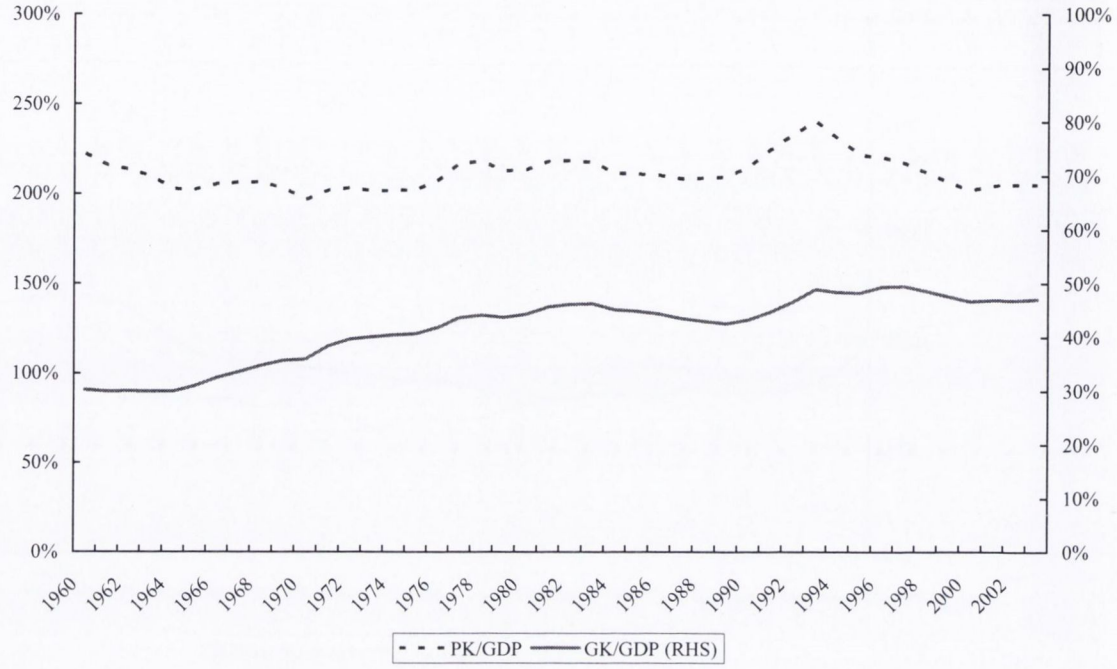


Chart 3.1rb - Sweden

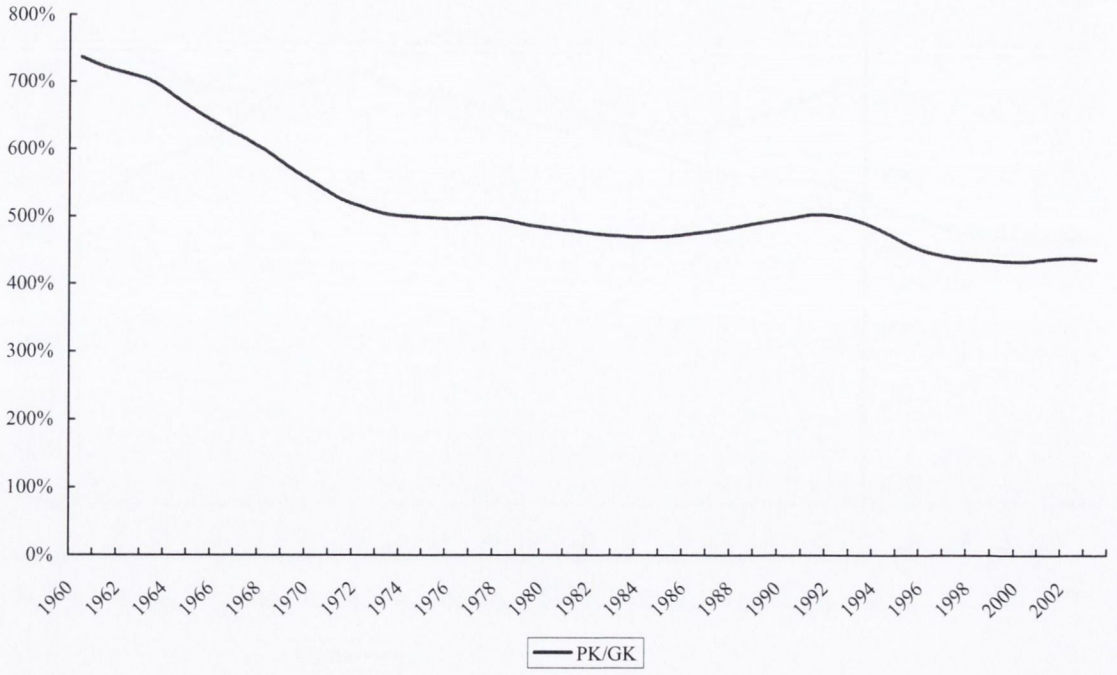


Chart 3.1sa - UK

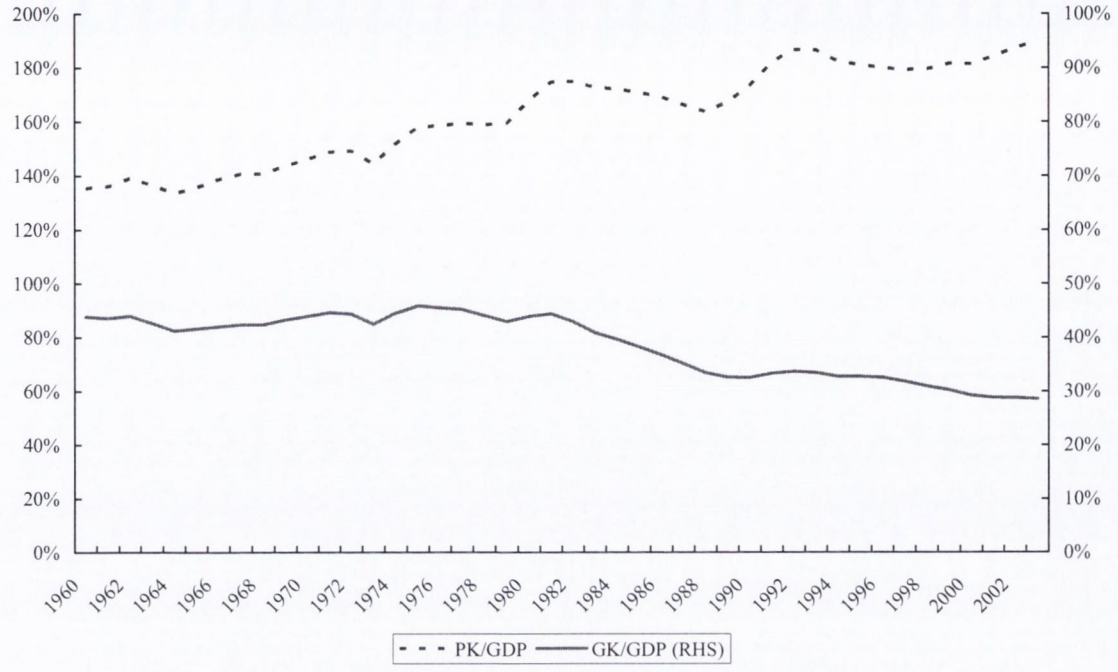


Chart 3.1sb - UK

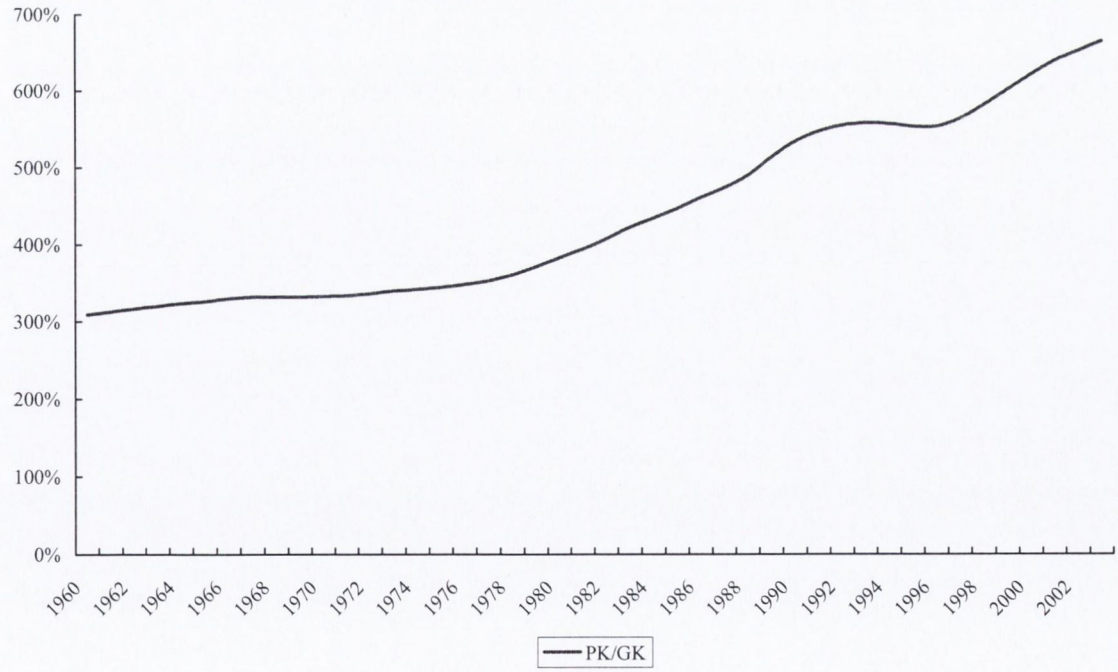


Chart 3.1ta - USA

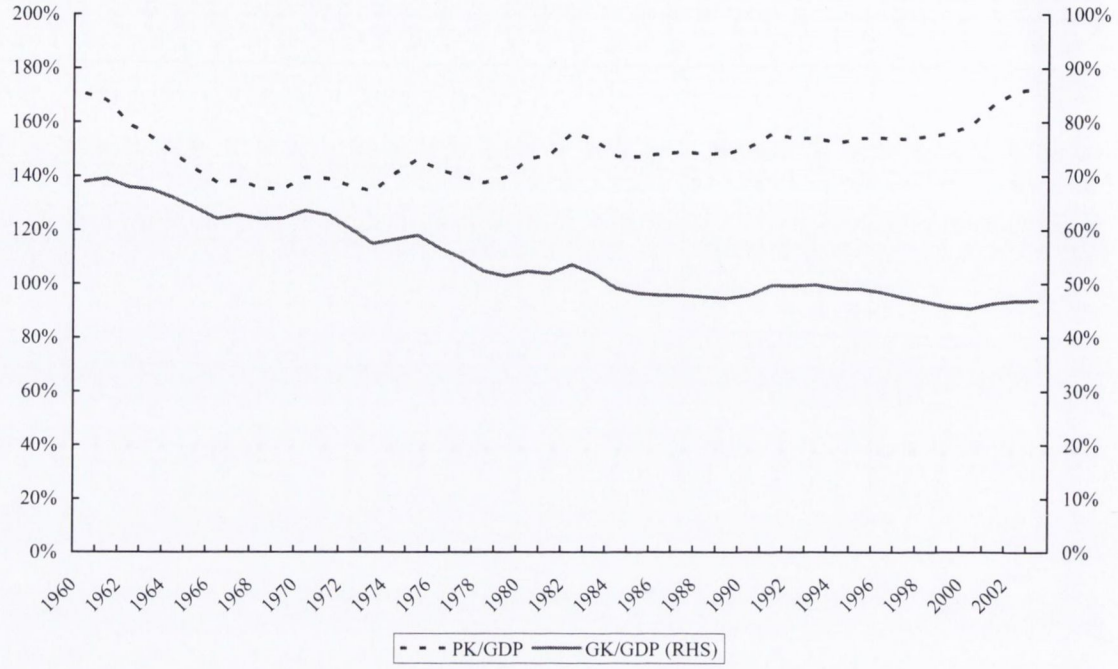


Chart 3.1tb - USA

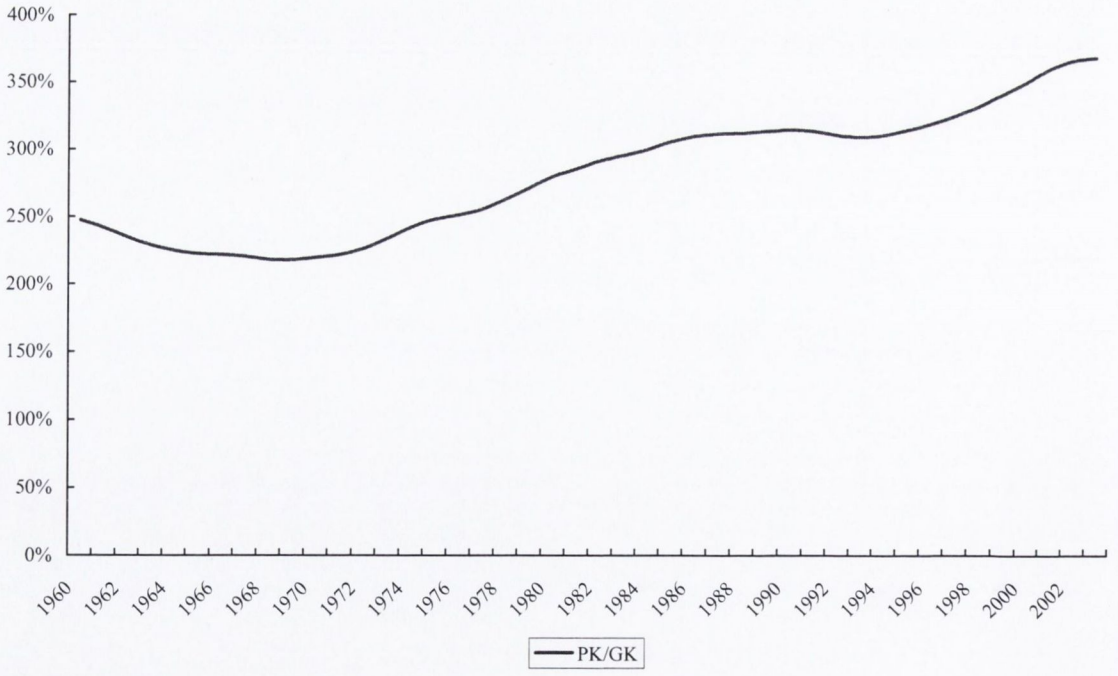
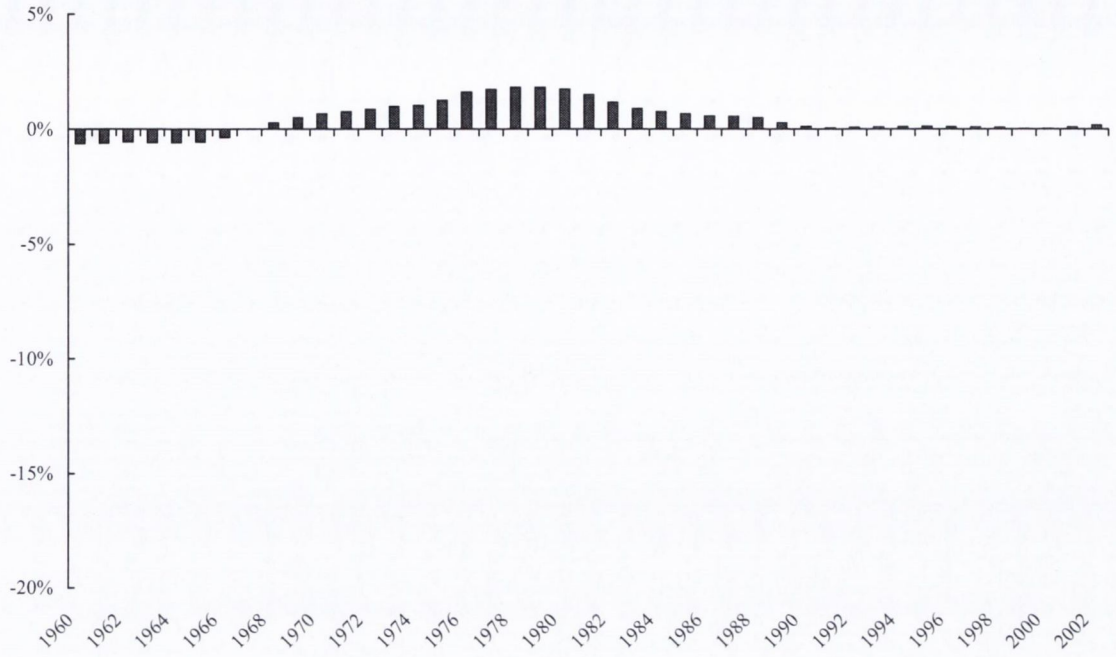
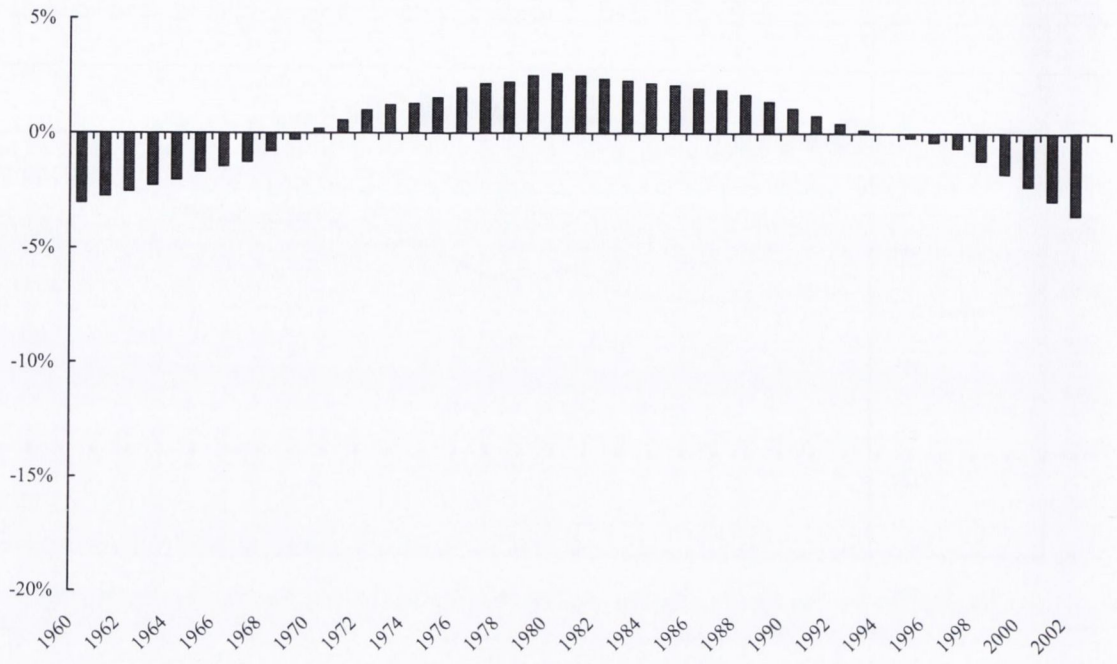


Chart 3.2a Australia - Capital Stock Imbalance/Total Capital Stock



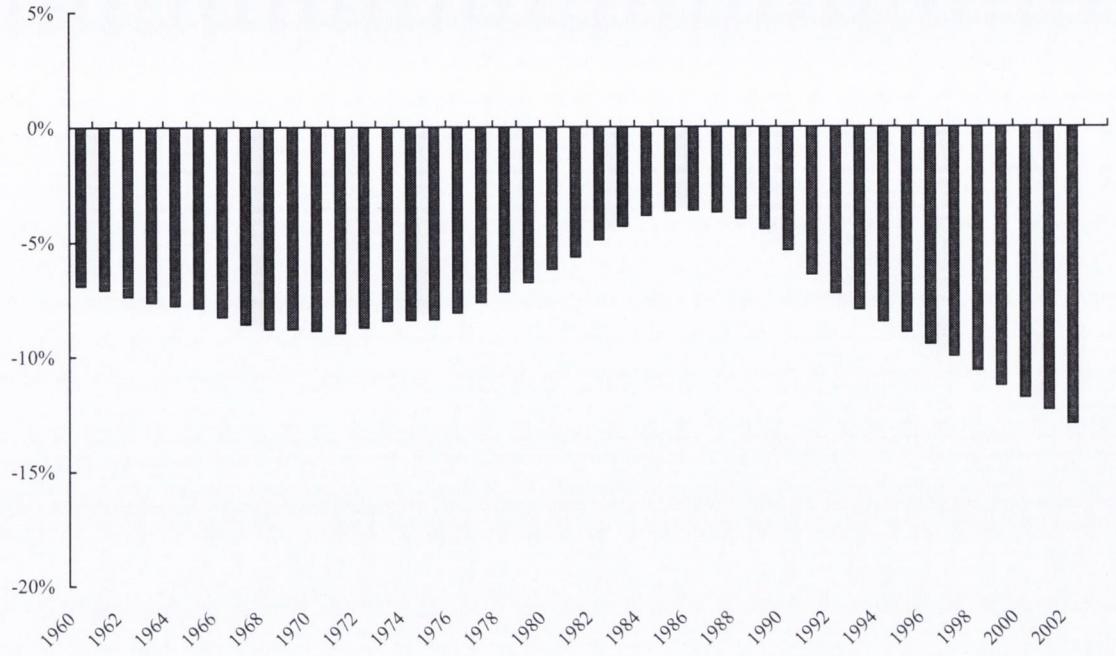
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2b Austria - Capital Stock Imbalance/Total Capital Stock



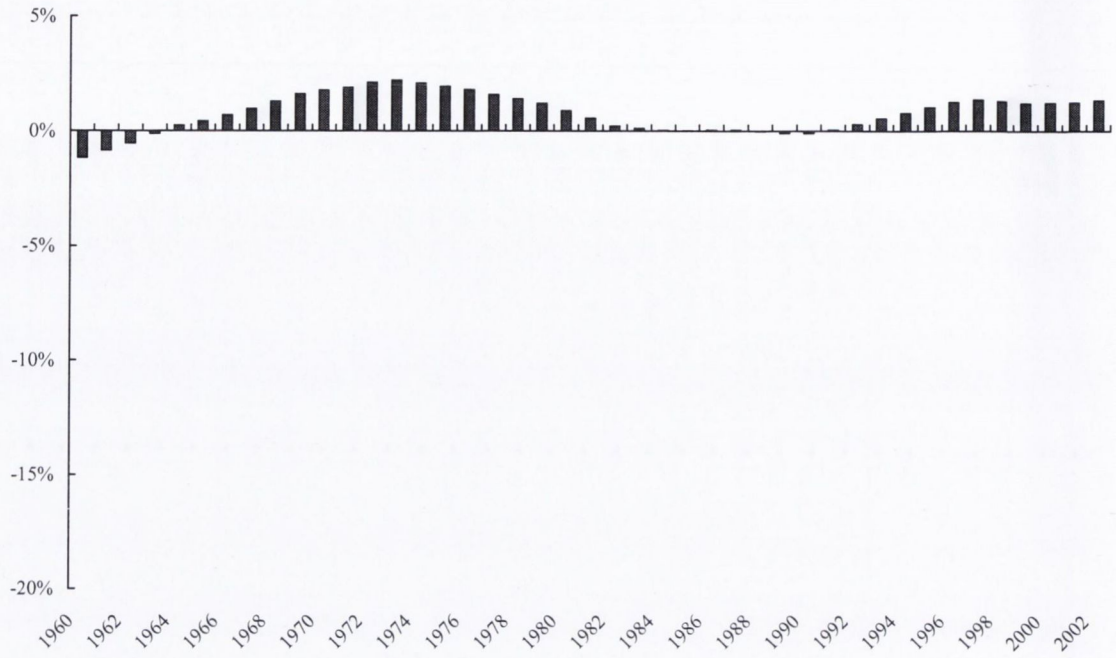
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2c Belgium - Capital Stock Imbalance/Total Capital Stock



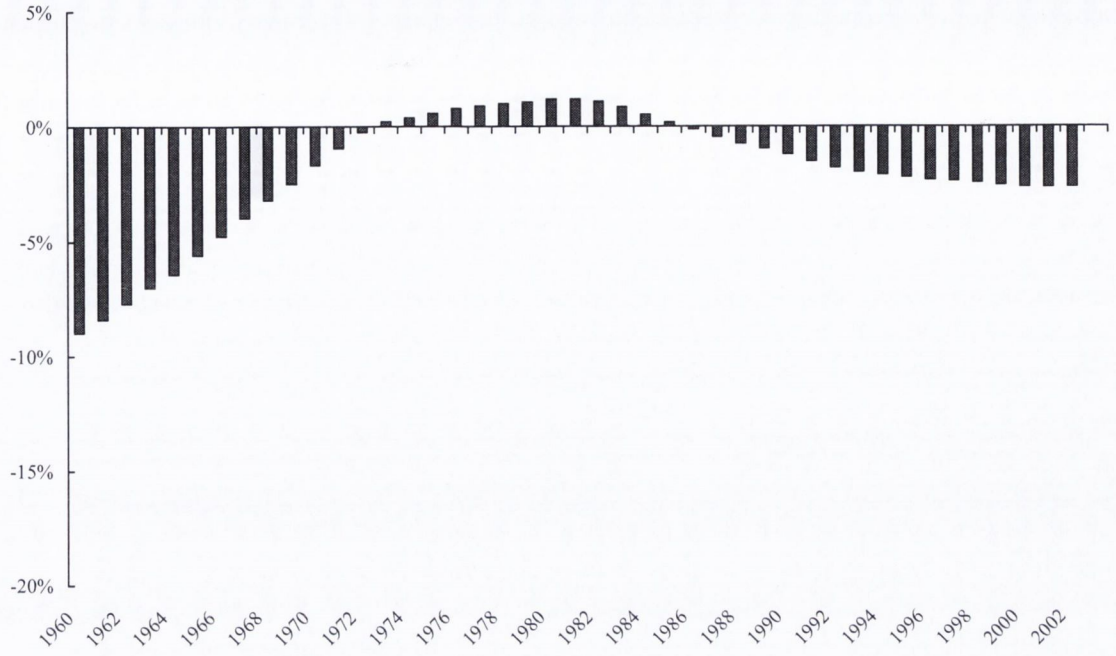
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2d Canada - Capital Stock Imbalance/Total Capital Stock



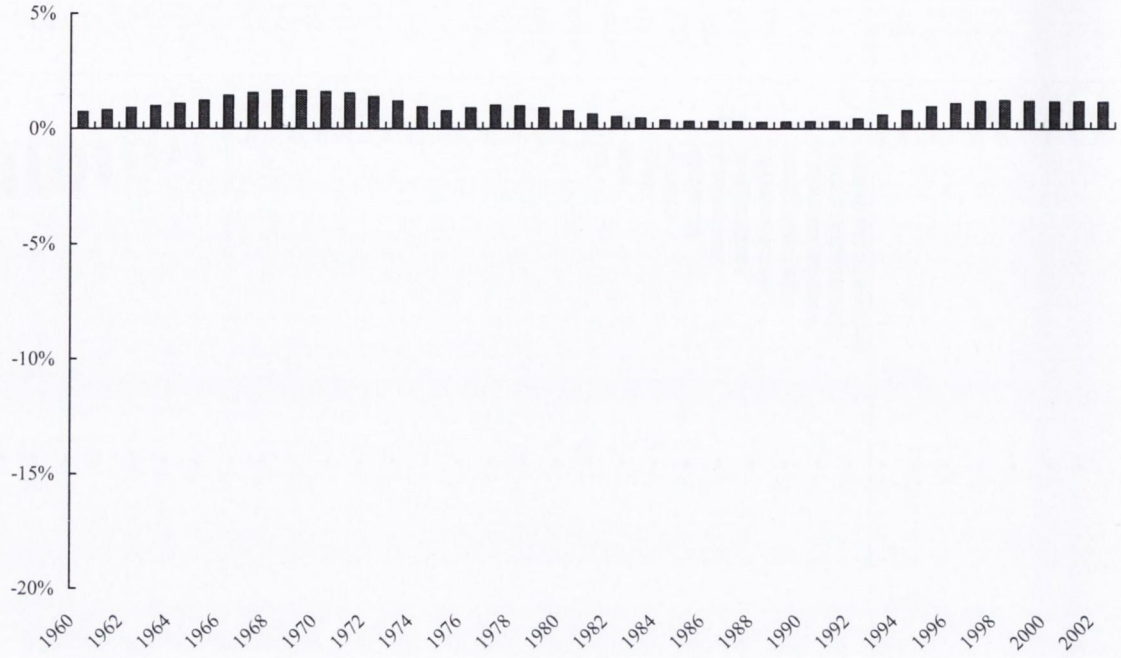
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2e Denmark - Capital Stock Imbalance/Total Capital Stock



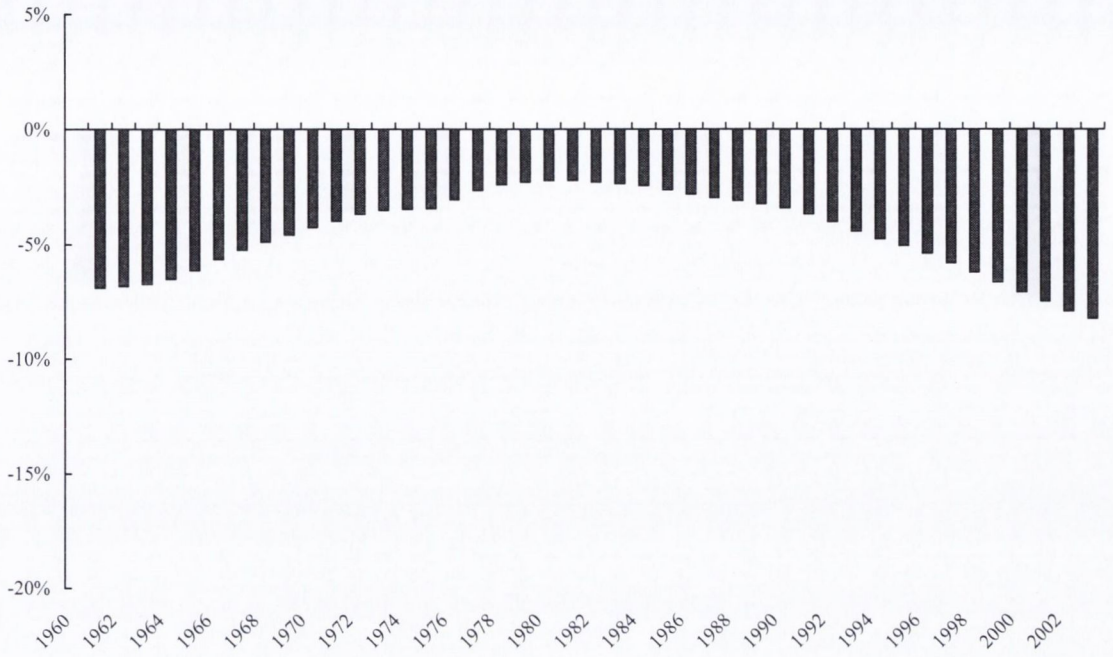
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2g France - Capital Stock Imbalance/Total Capital Stock



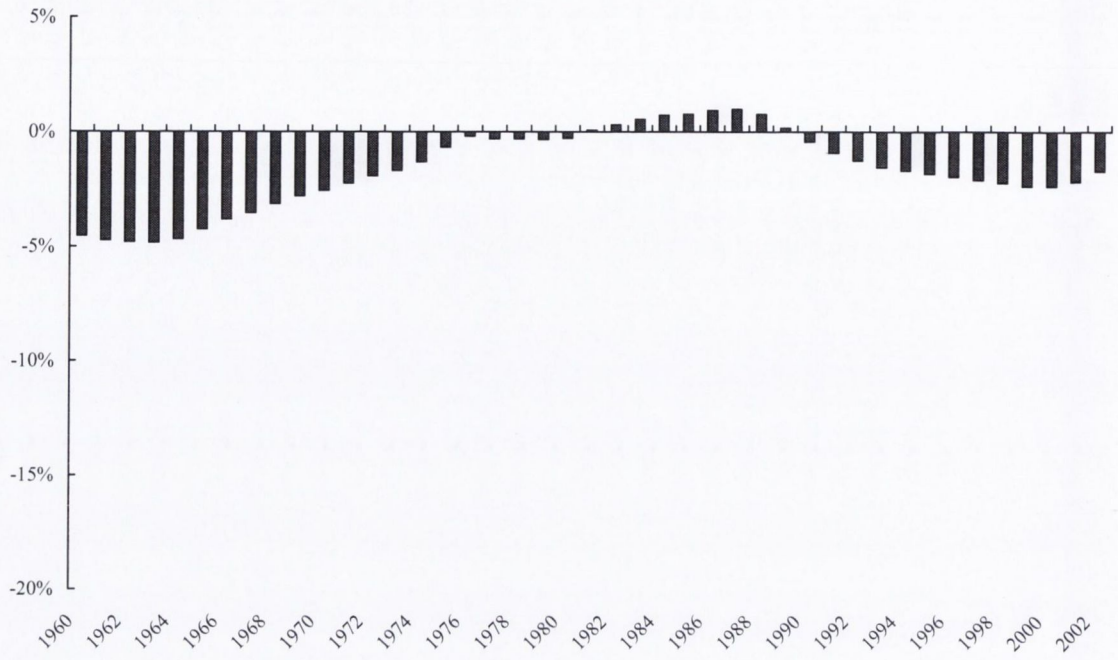
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2h Germany - Capital Stock Imbalance/Total Capital Stock



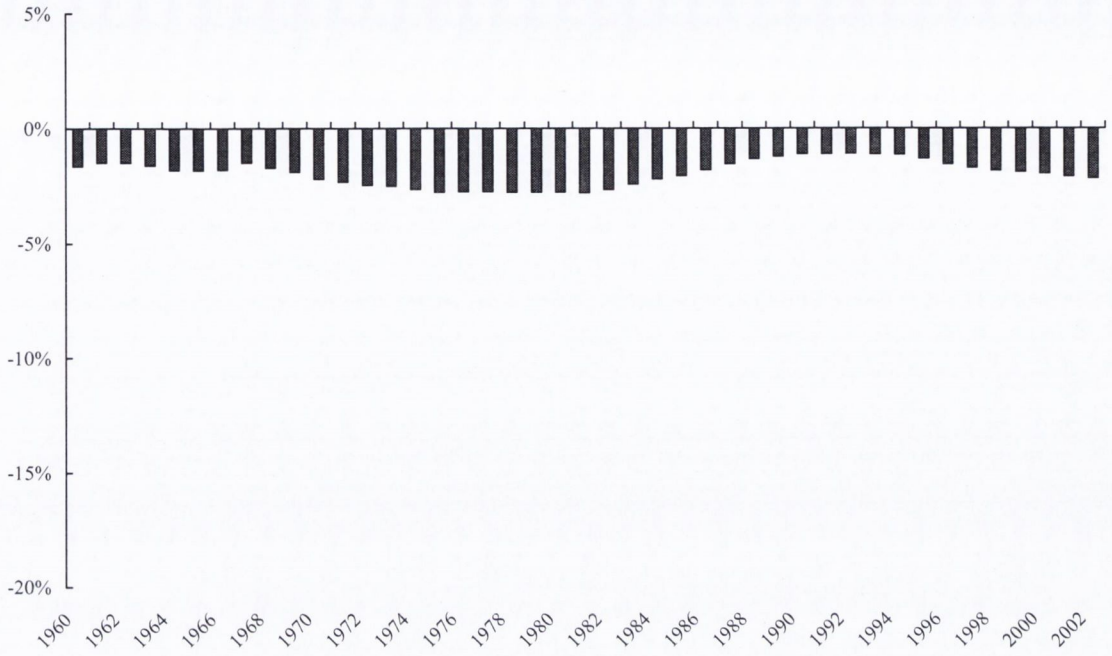
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2j Ireland - Capital Stock Imbalance/Total Capital Stock



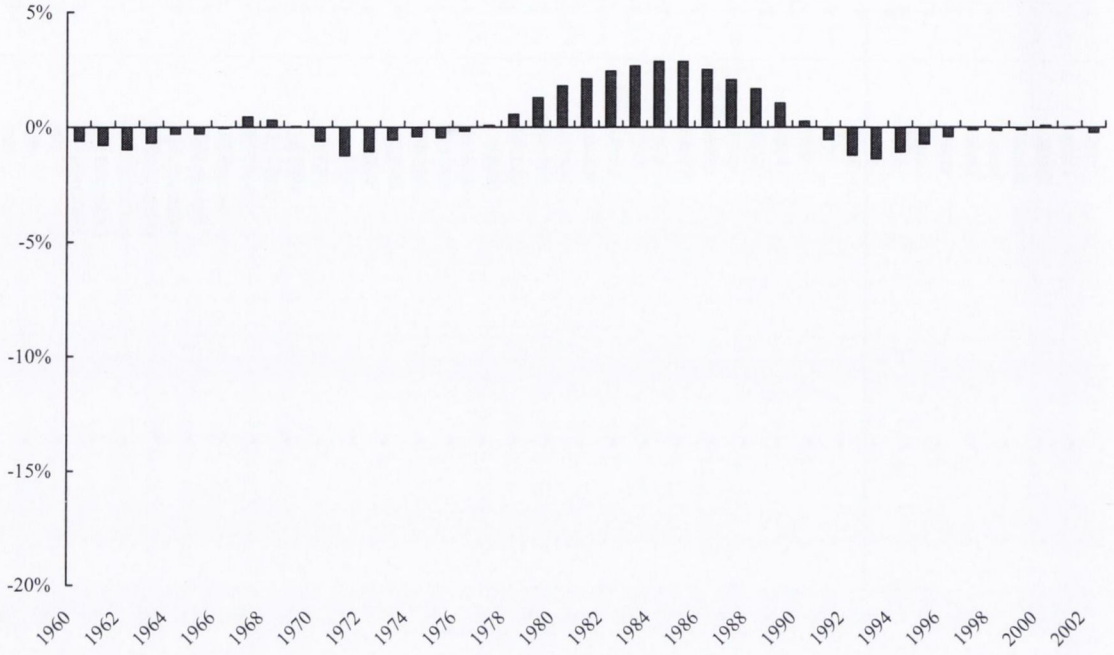
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2k Italy - Capital Stock Imbalance/Total Capital Stock



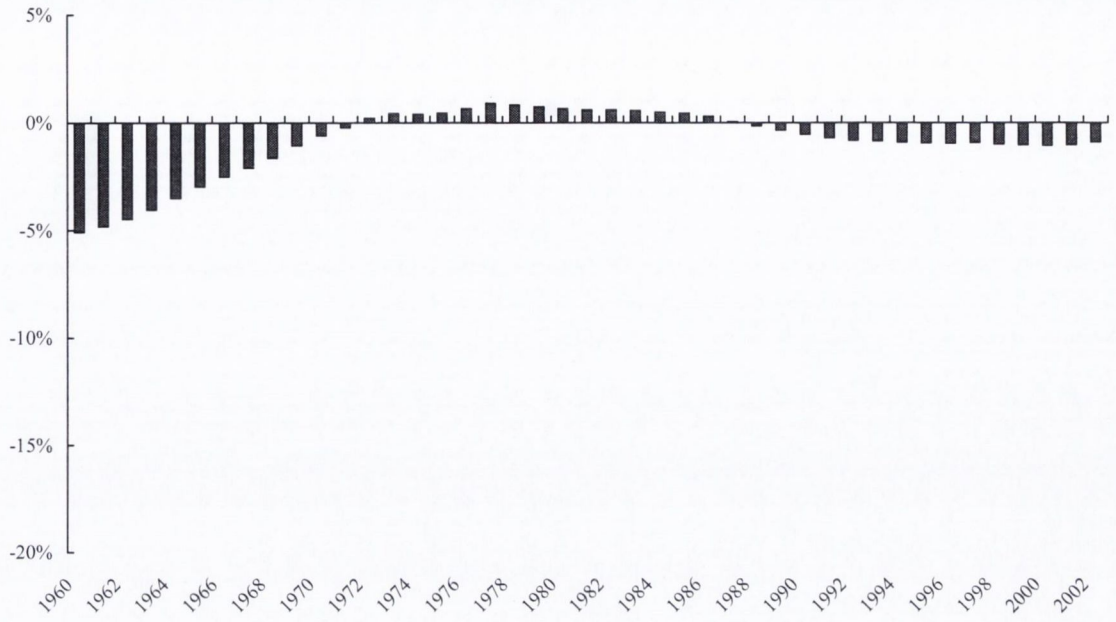
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2i Japan - Capital Stock Imbalance/Total Capital Stock



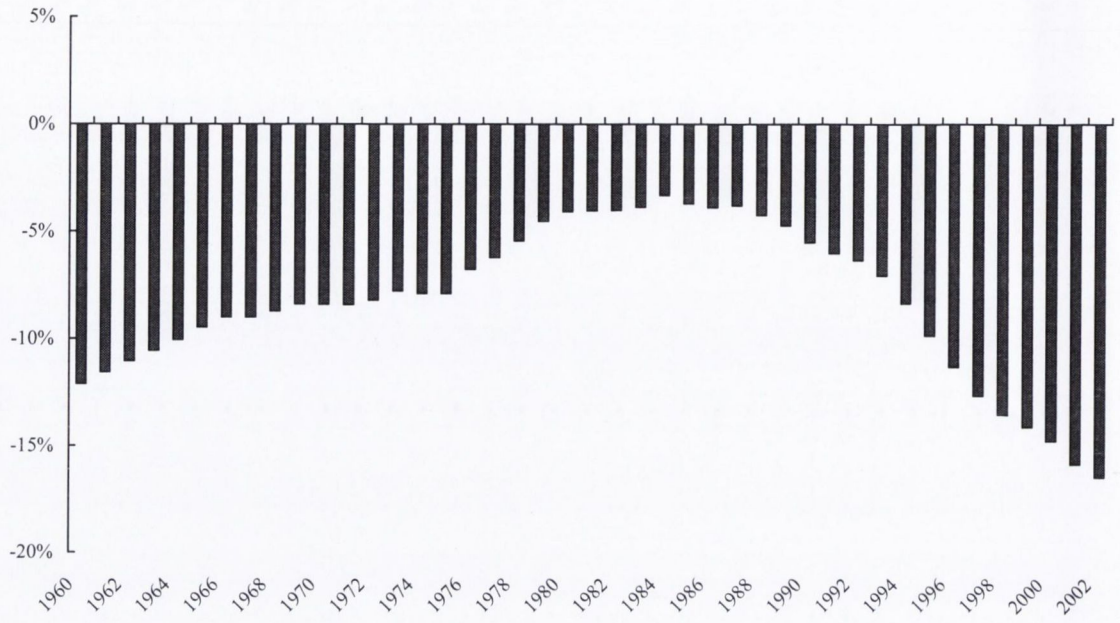
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2m Netherlands Capital Stock Imbalance /Total Capital Stock



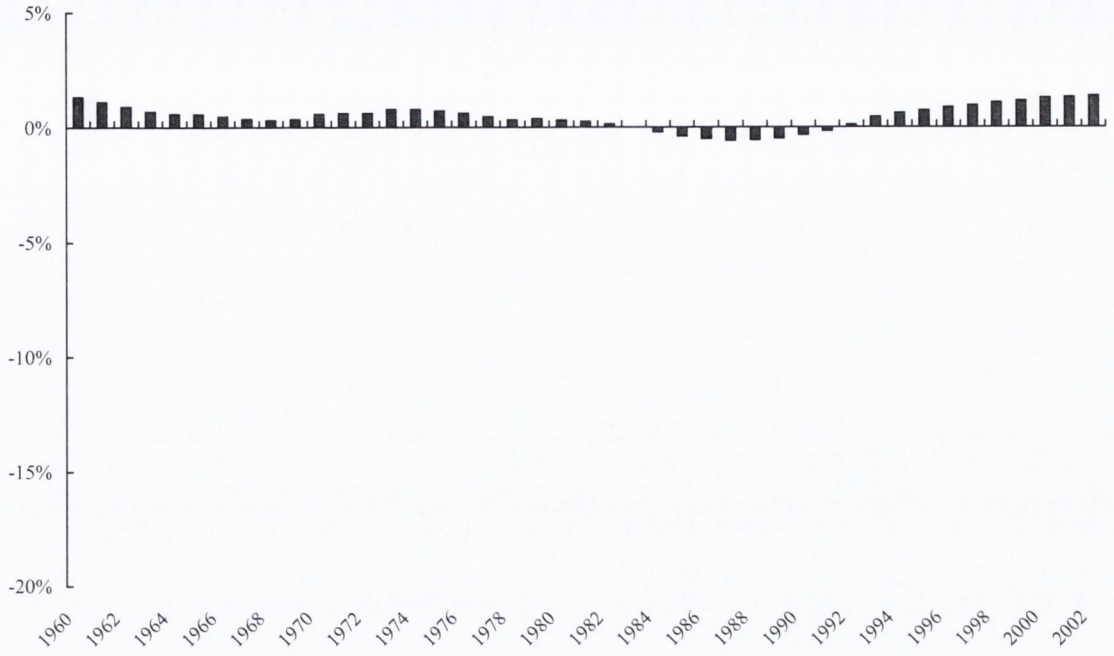
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2n New Zealand Capital Stock Imbalance/Total Capital Stock



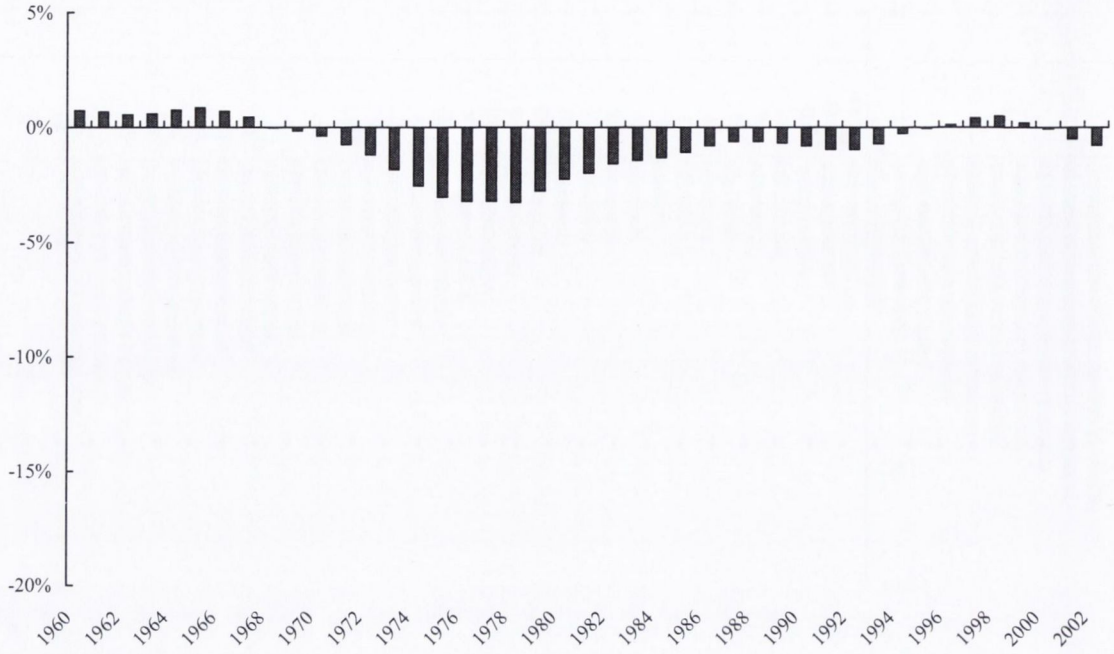
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2o Norway - Capital Stock Imbalance/Total Capital Stock



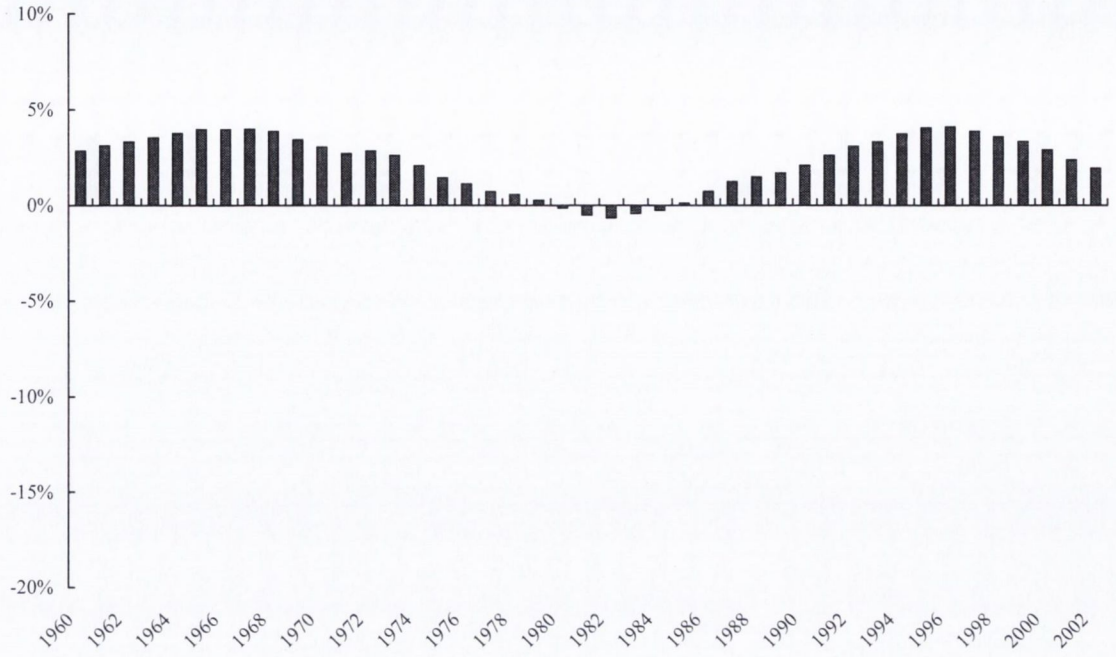
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2p Portugal - Capital Stock Imbalance/Total Capital Stock



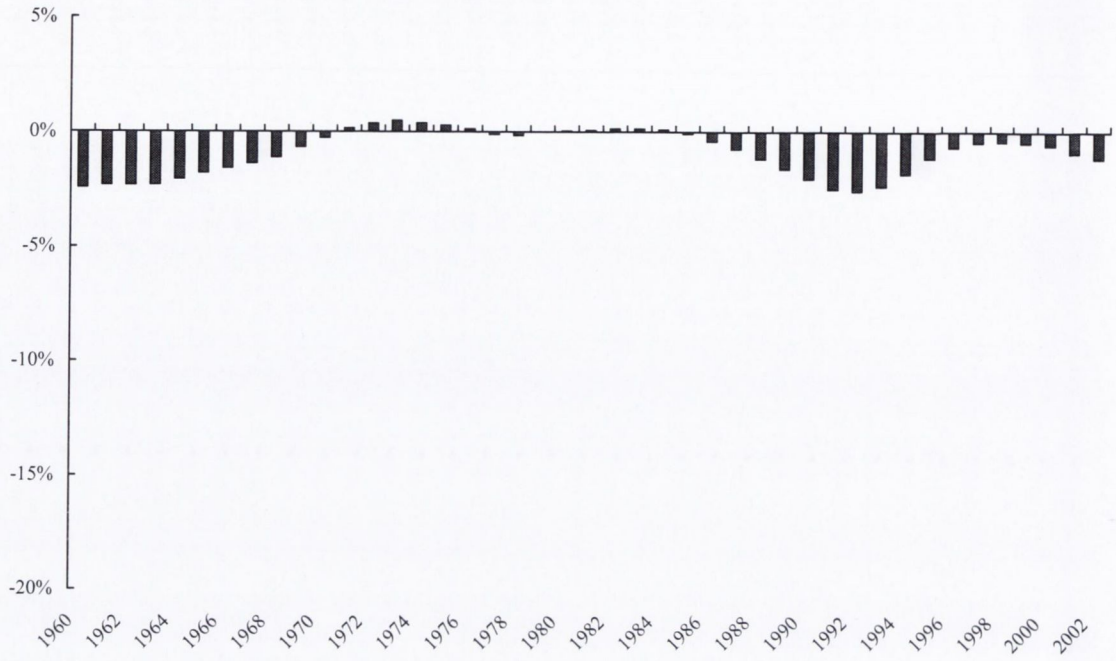
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2q Spain - Capital Stock Imbalance/Total Capital Stock



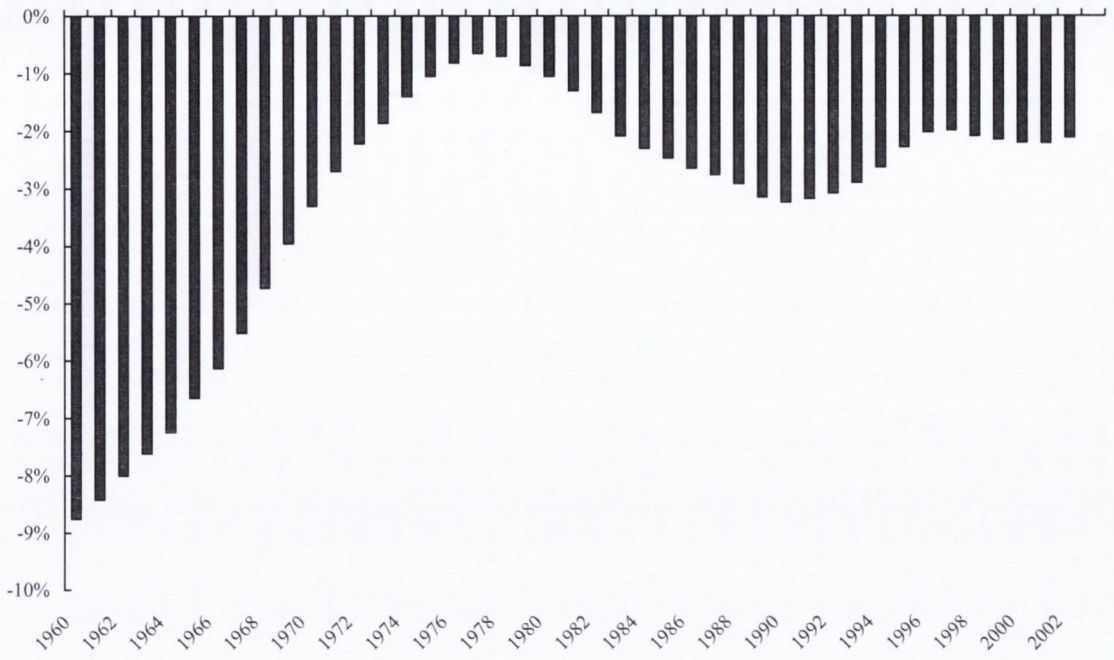
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2r Sweden - Capital Stock Imbalance/Total Capital Stock



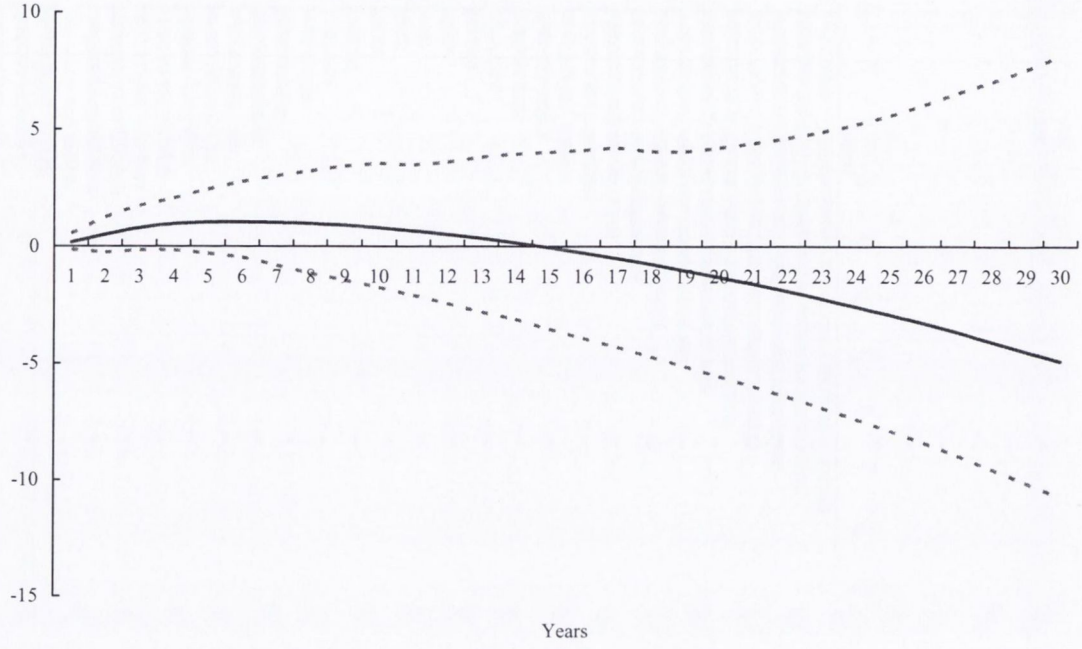
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.2s UK - Capital Stock Imbalance/Total Capital Stock



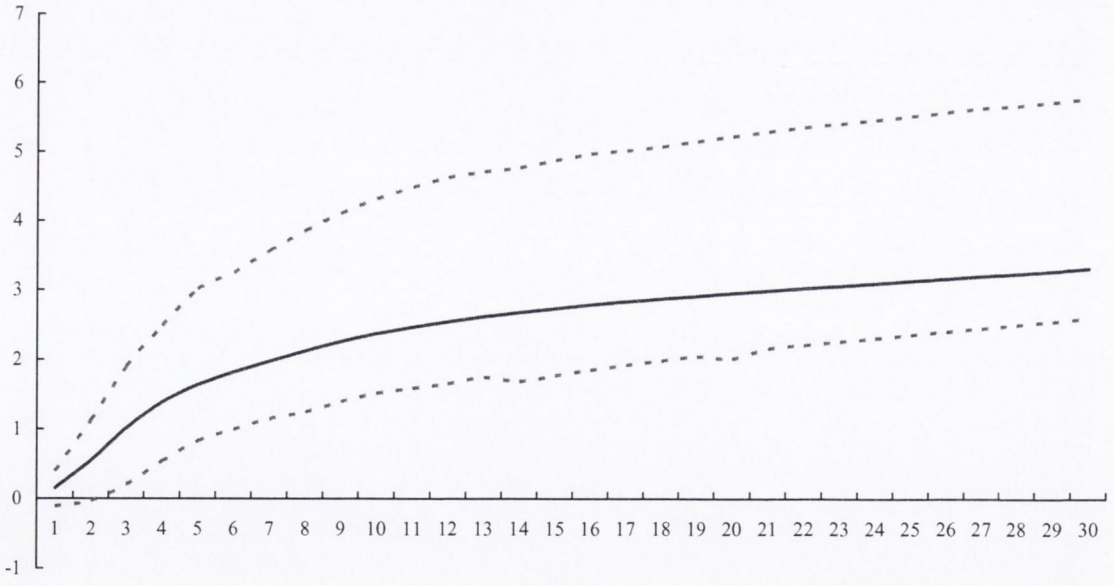
Note: Positive imbalances reflect a relatively plentiful public capital stock and negative imbalances reflect a relatively plentiful private capital stock

Chart 3.3aa Austria - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment



Years

Chart 3.3ab Austria - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment



Years

Chart 3.3ba Australia- Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

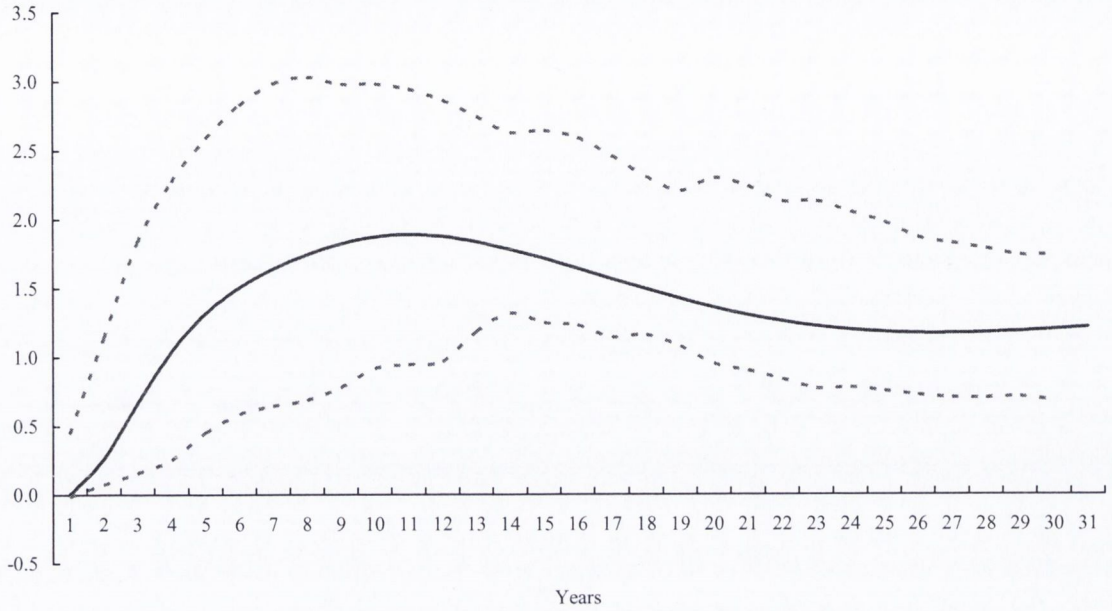


Chart 3.3bb Australia - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

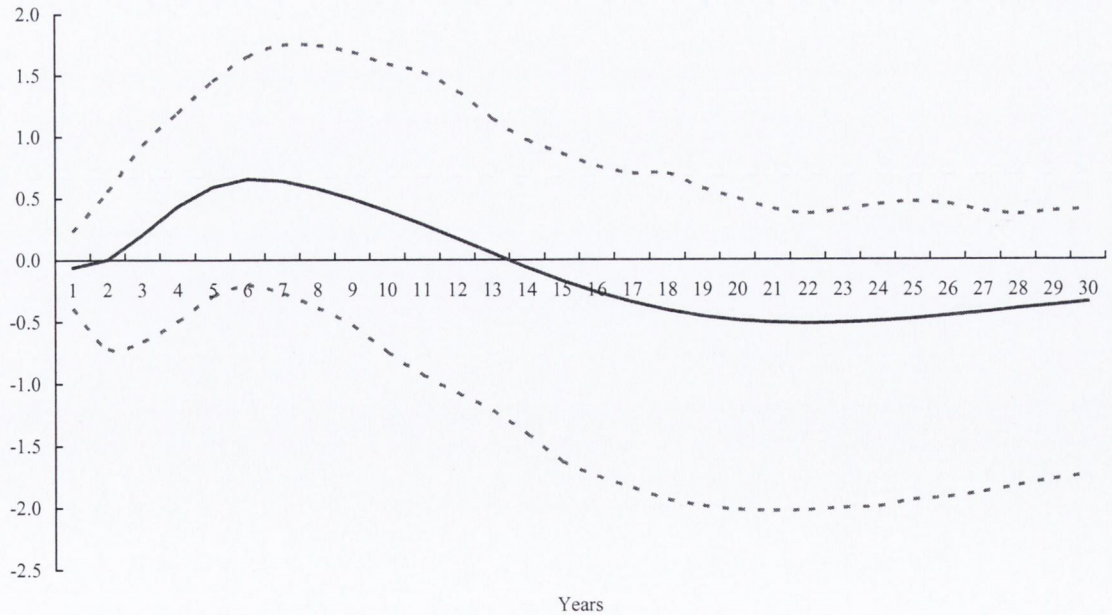
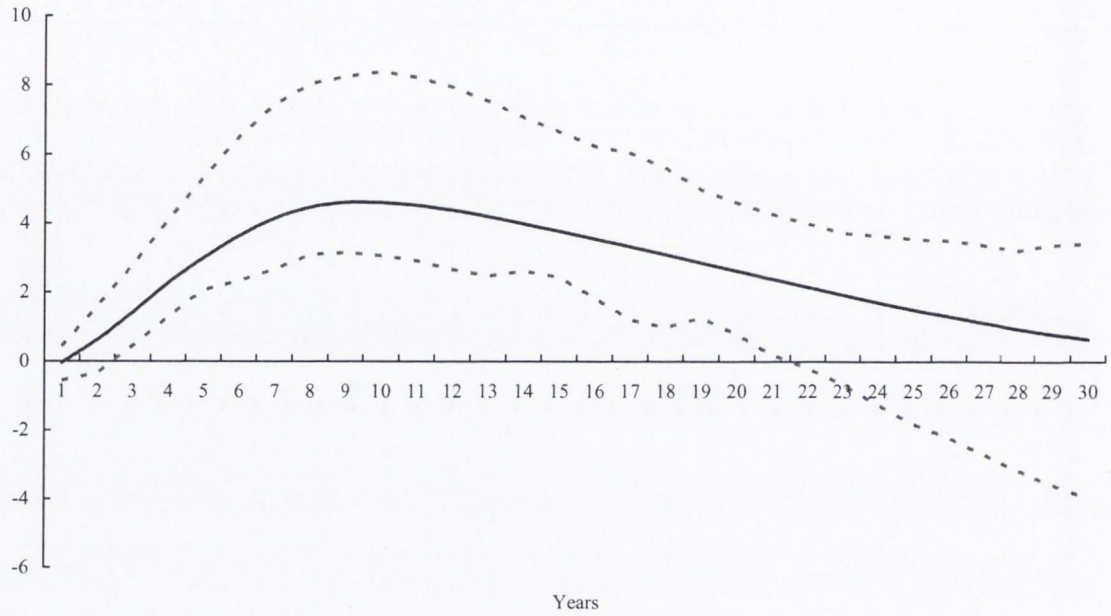
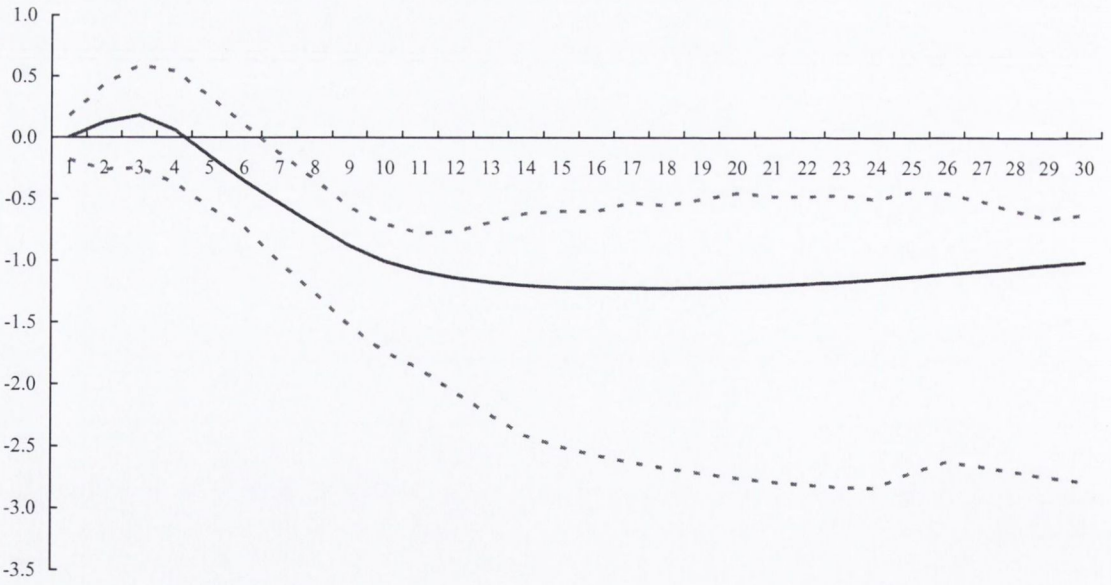


Chart 3.3ca Belgium - Impulse Response of Public Investment to a 1.S.D Shock to Private Investment



Years

Chart 3.3cb Belgium - Impulse Reponse of Private Investment to a 1 S.D. Shock to Public Investment



Years

Chart 3.3da Canada - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

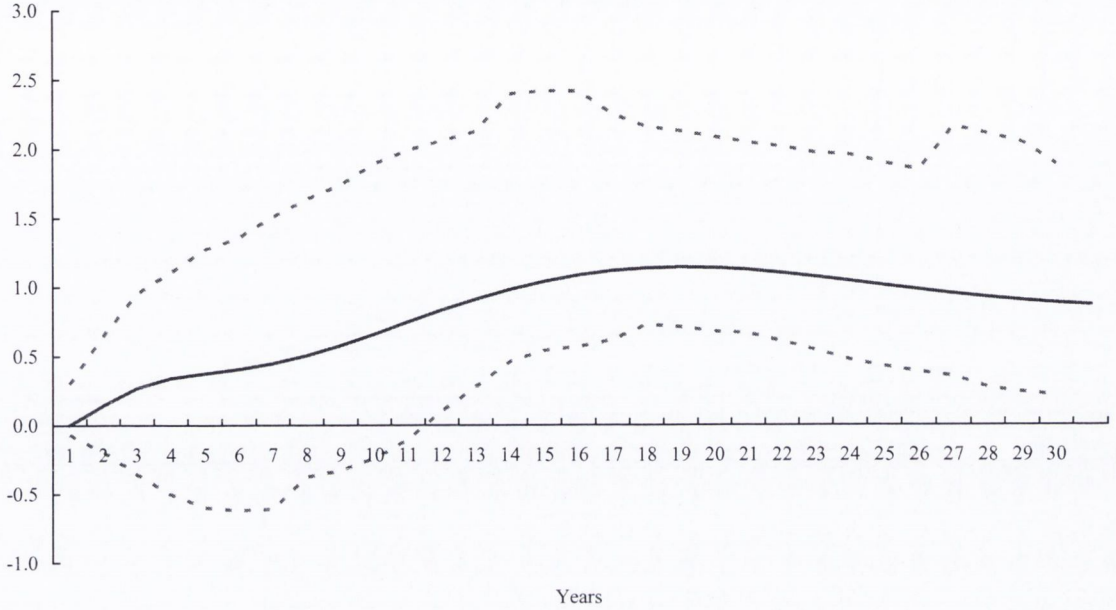


Chart 3.3db Canada - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

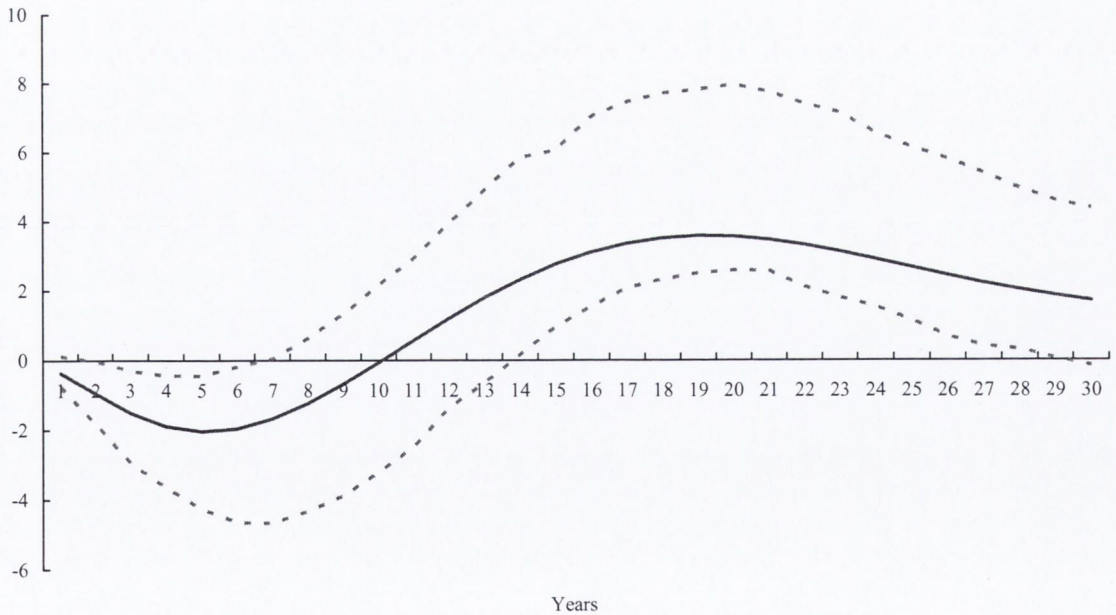
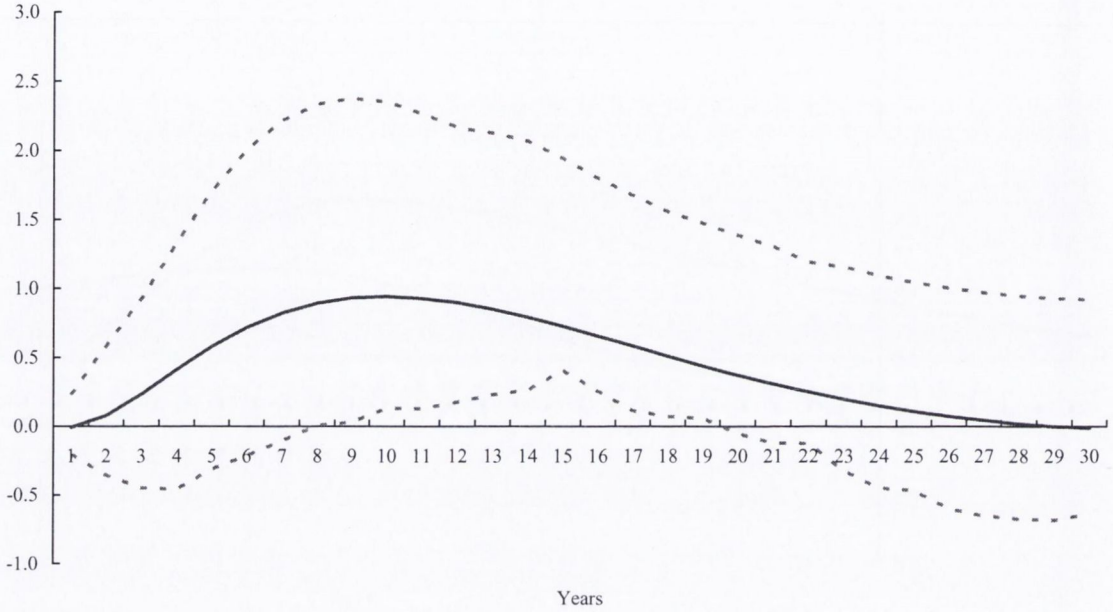
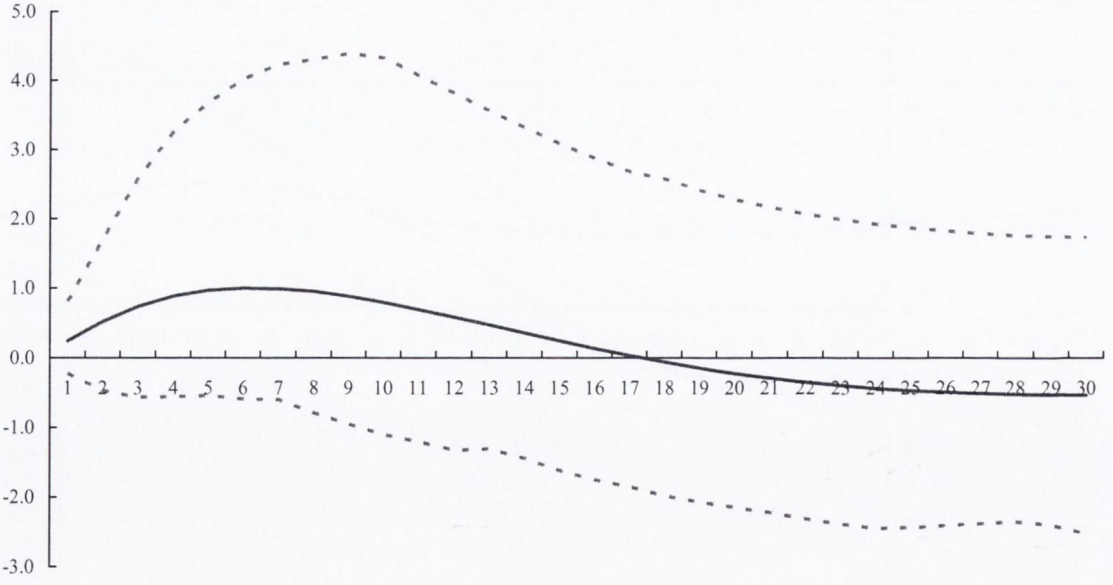


Chart 3.3ea Denmark - Impulse Reponse of Public Investment to a 1 S.D. Shock to Private Investment



Years

Chart 3.3eb Denmark - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment



Years

Chart 3.3fa Finland - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

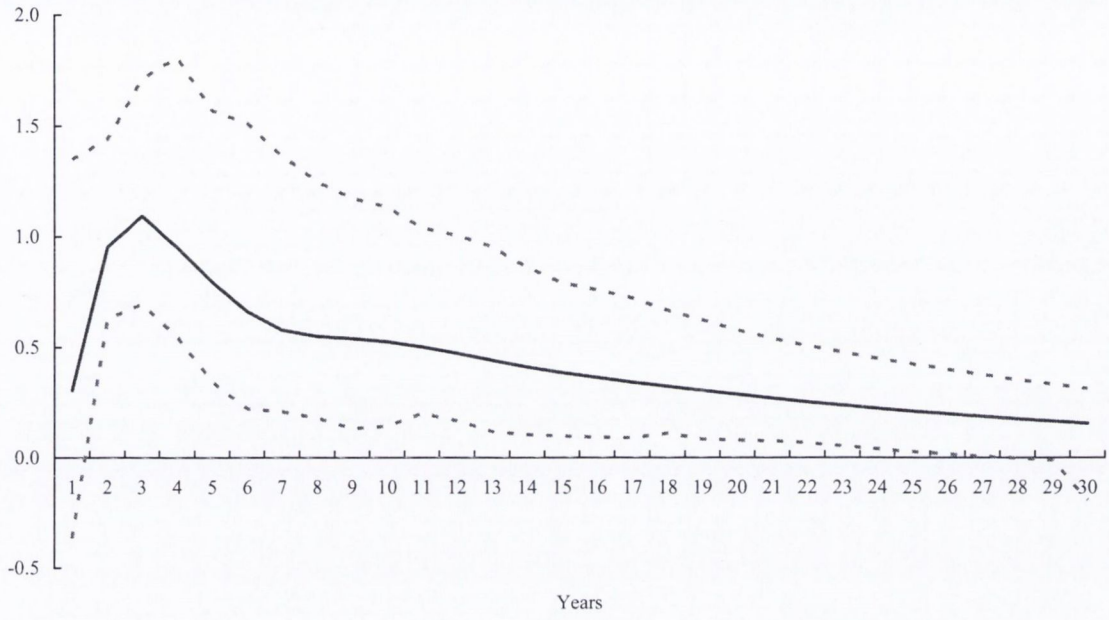


Chart 3.3fb Finland - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

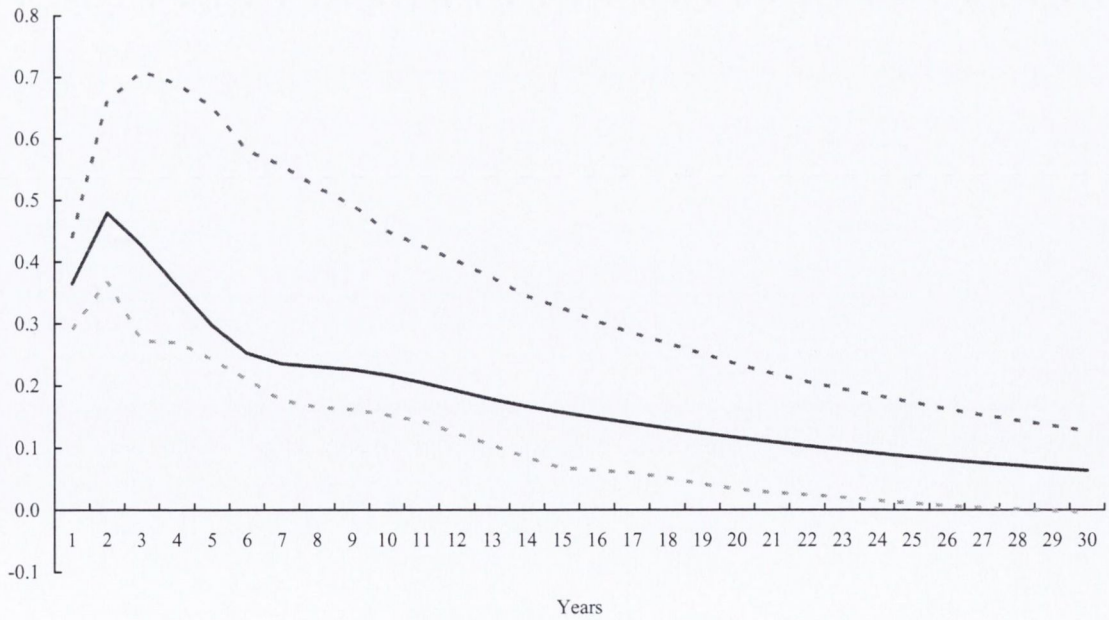
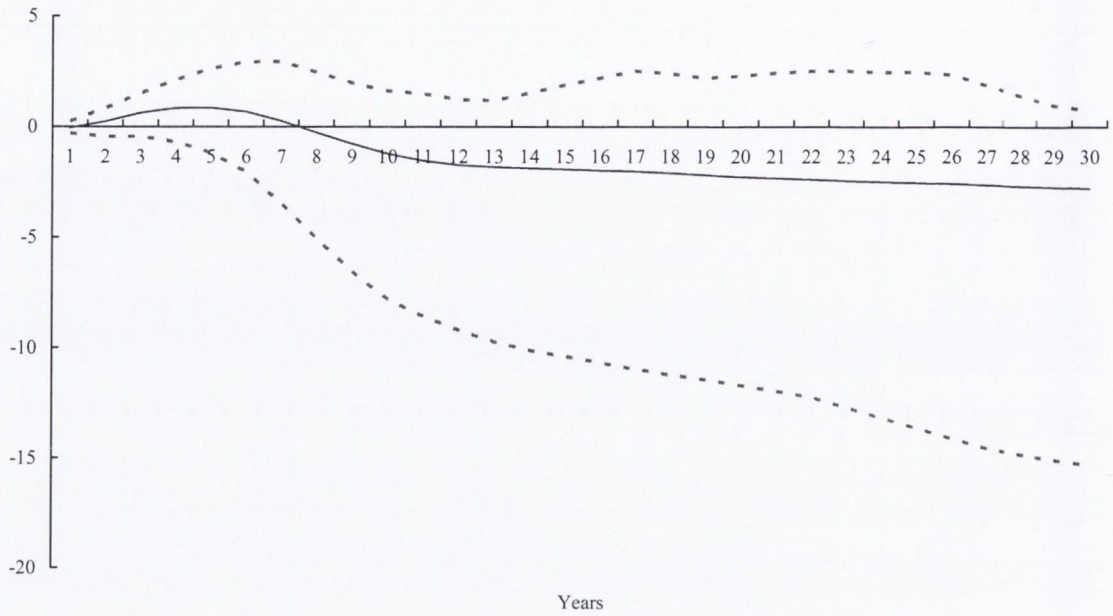
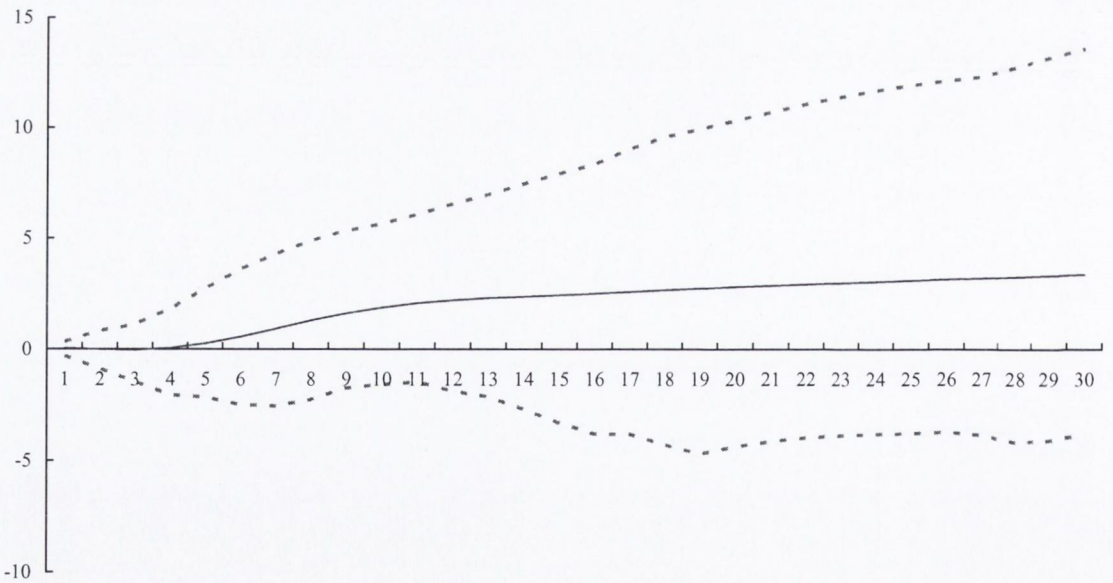


Chart 3.3ga France - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment



Years

Chart 3.3gb France - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment



Years

Chart 3.3ha Germany - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

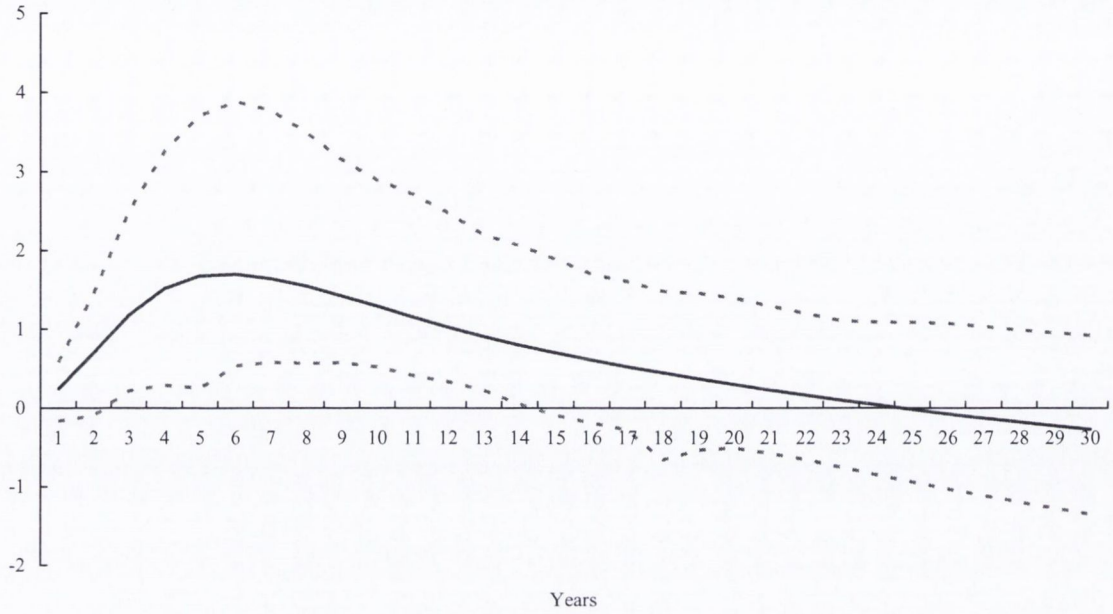


Chart 3.3hb Germany - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

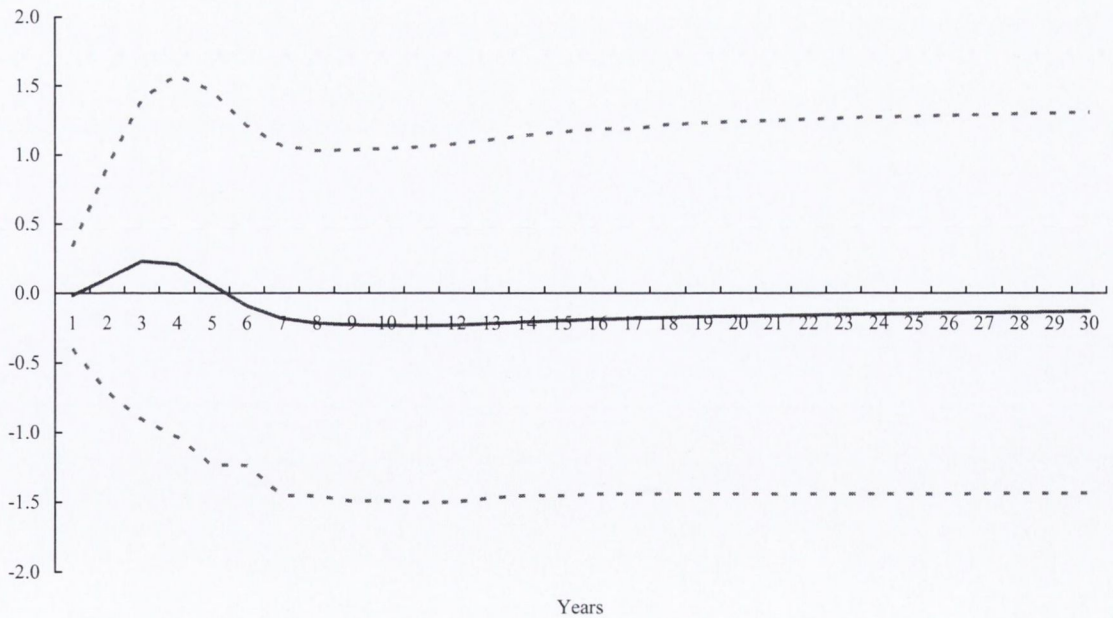


Chart 3.3ia Greece - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

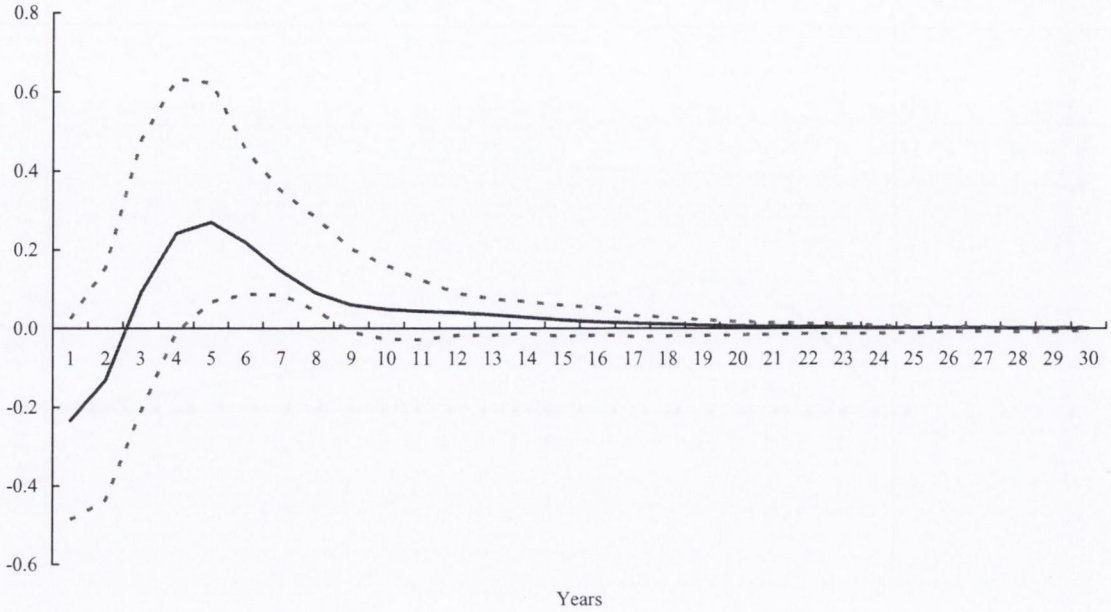


Chart 3.3ib Greece - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

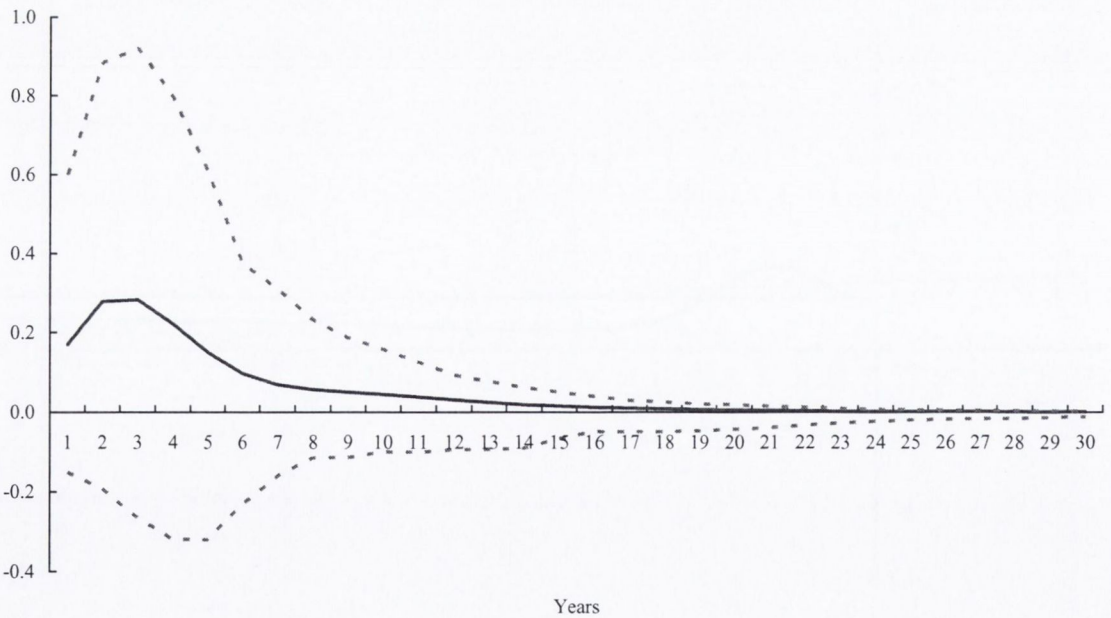


Chart 3.3ja Ireland - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

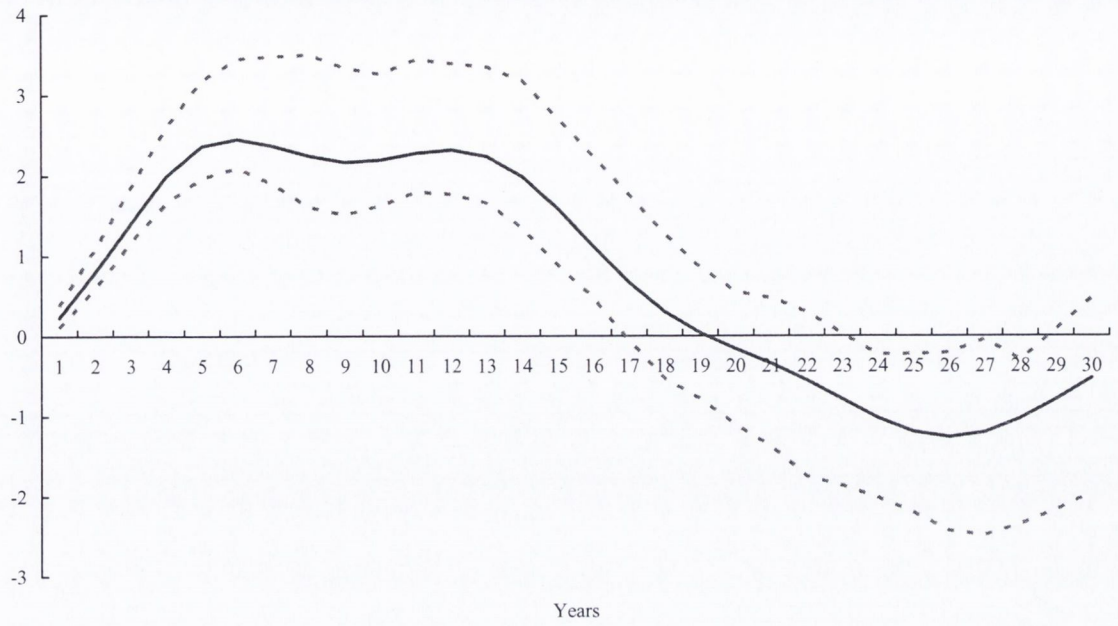


Chart 3.3jb Ireland - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

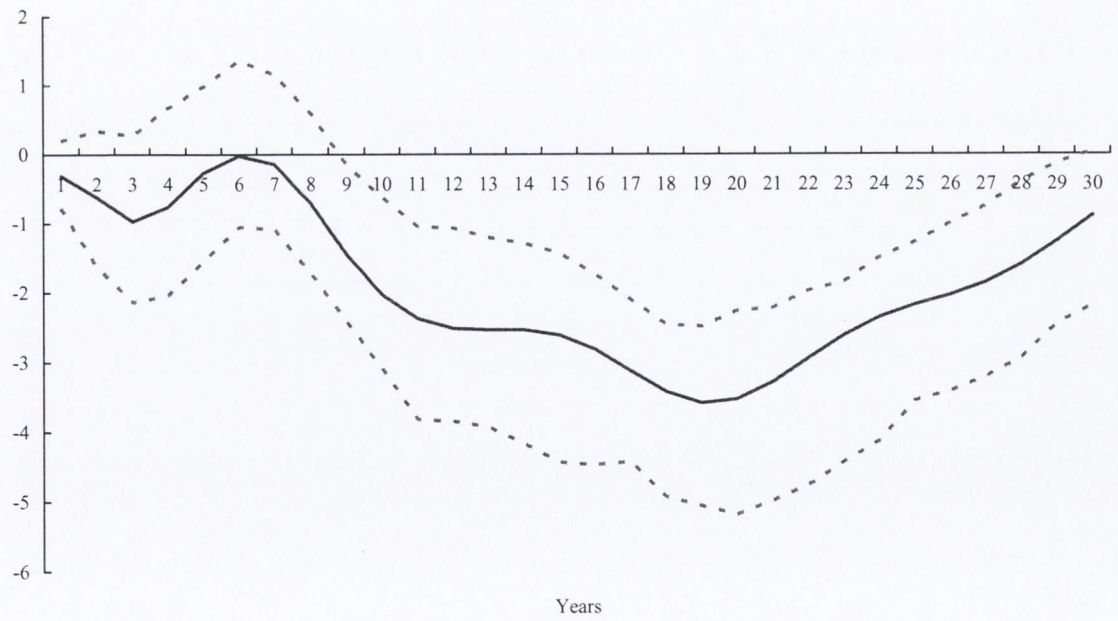


Chart 3.3ka Italy - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

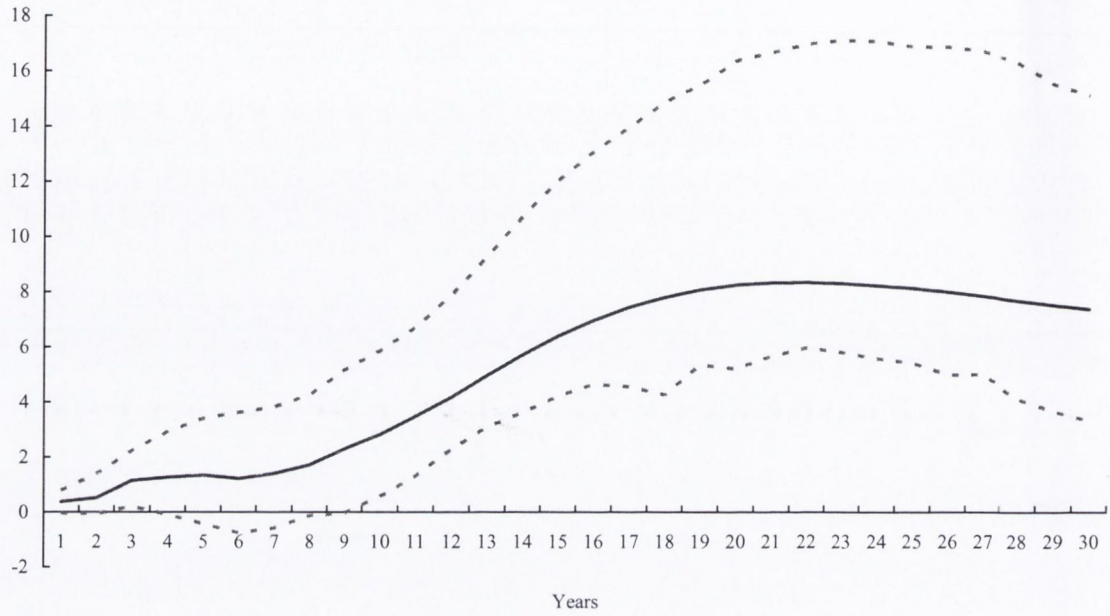


Chart 3.3kb Italy - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

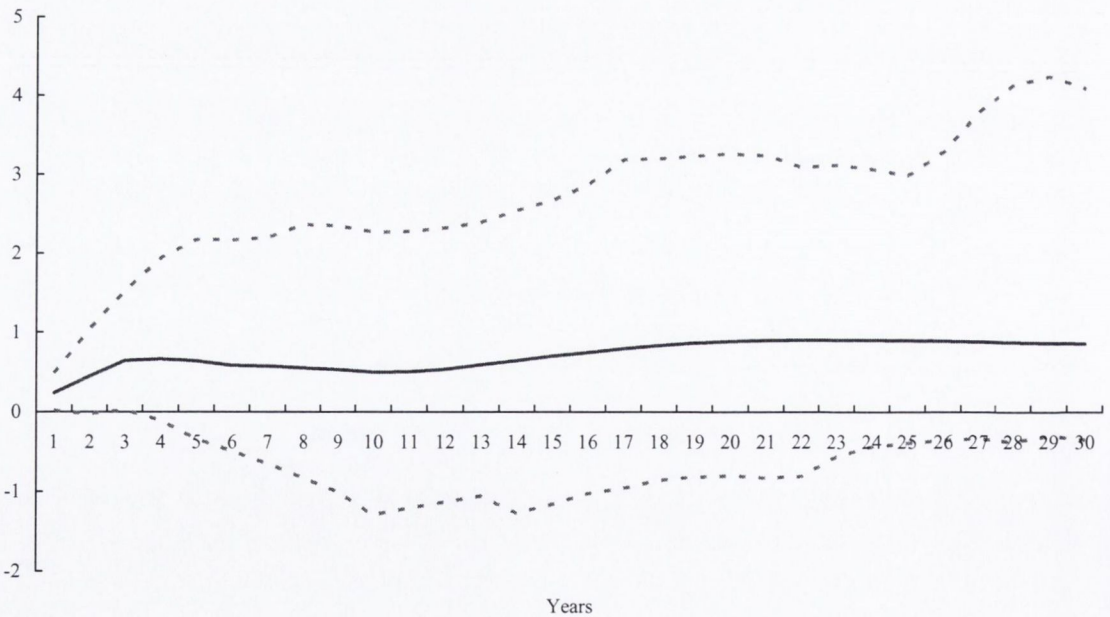


Chart 3.3la Japan - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

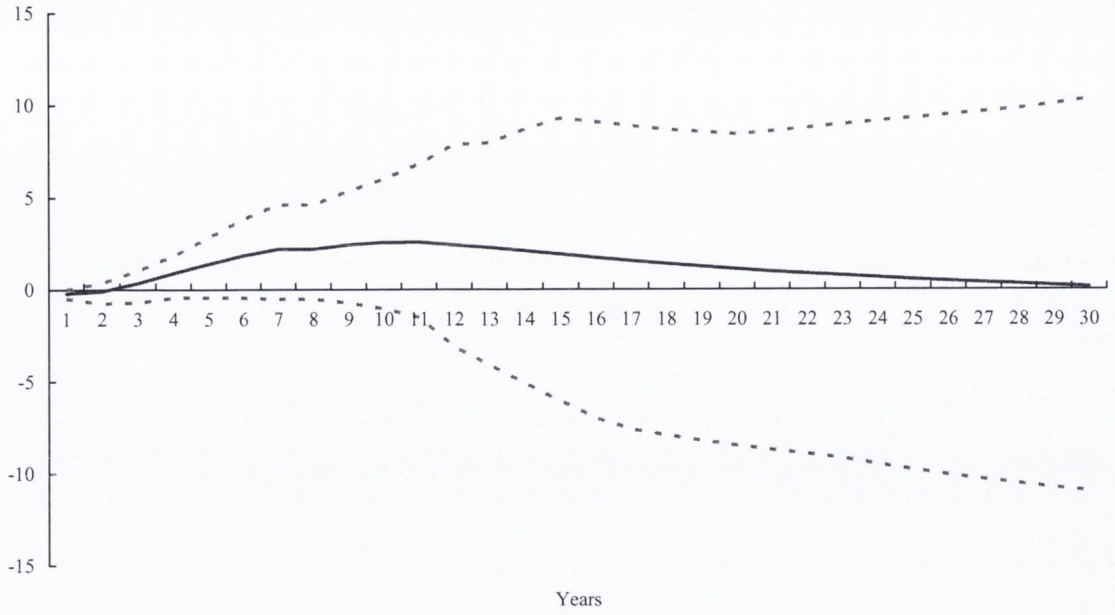


Chart 3.3lb Japan - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

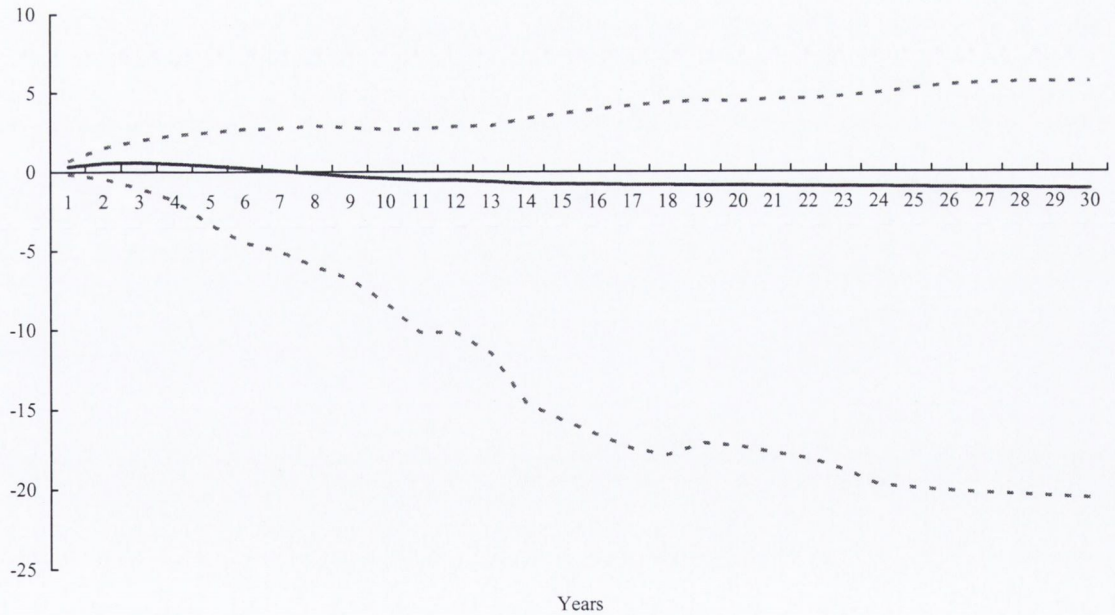


Chart 3.3ma Netherlands - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

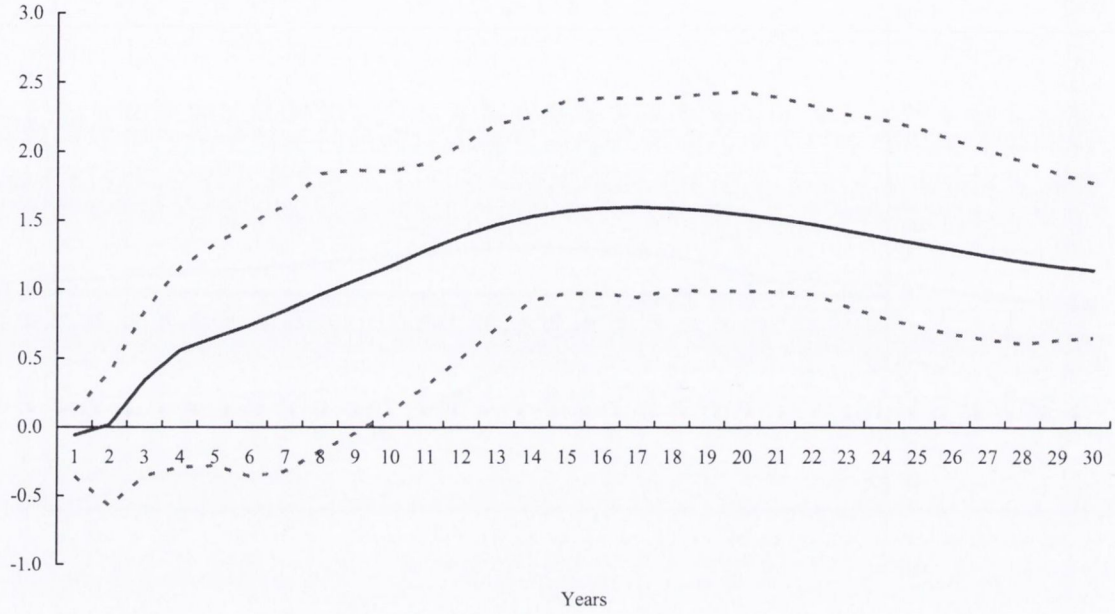


Chart 3.3mb Netherlands - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

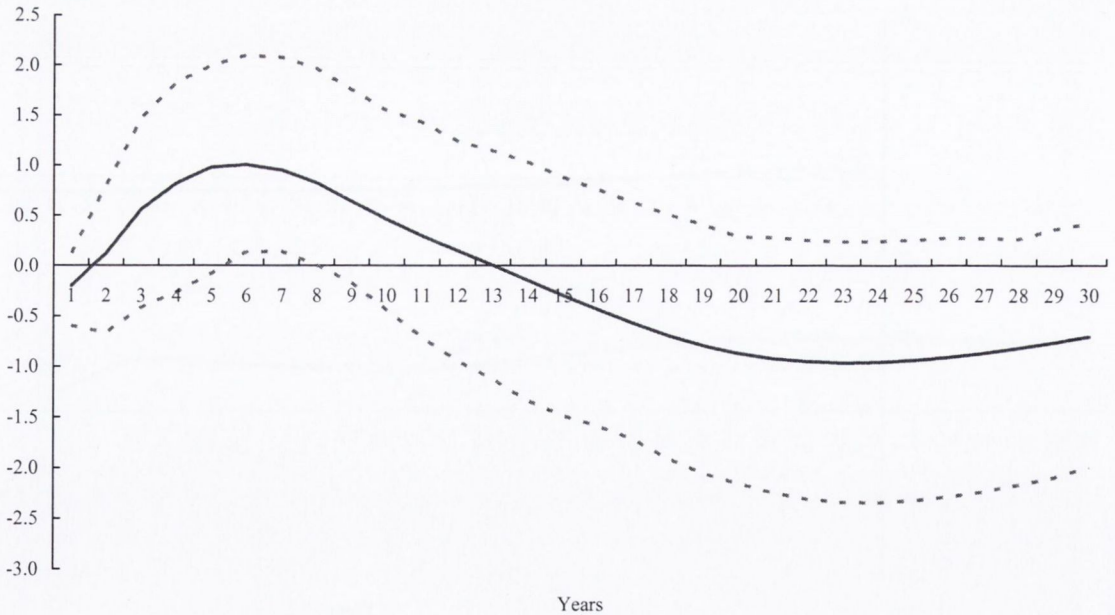


Chart 3.3na New Zealand - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

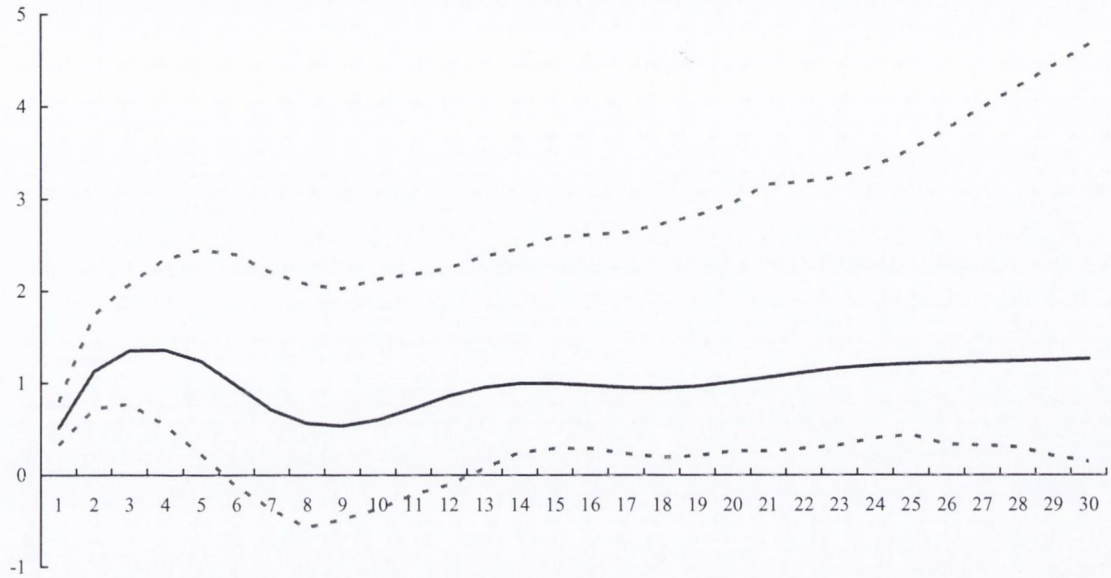


Chart 3.3nb New Zealand - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

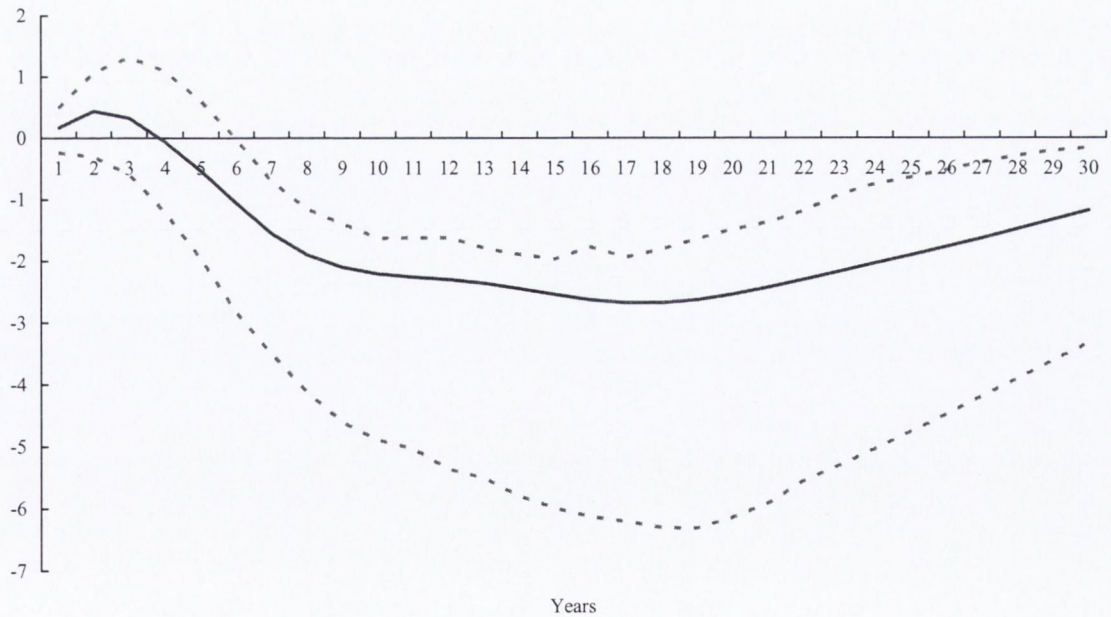


Chart 3.3oa Norway - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

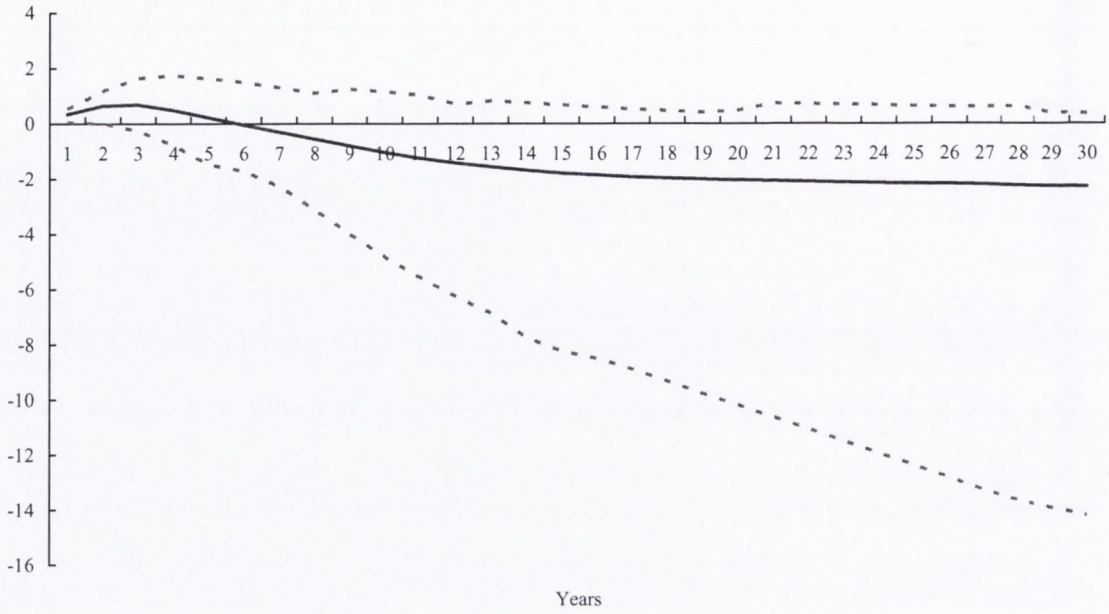


Chart 3.3ob Norway - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

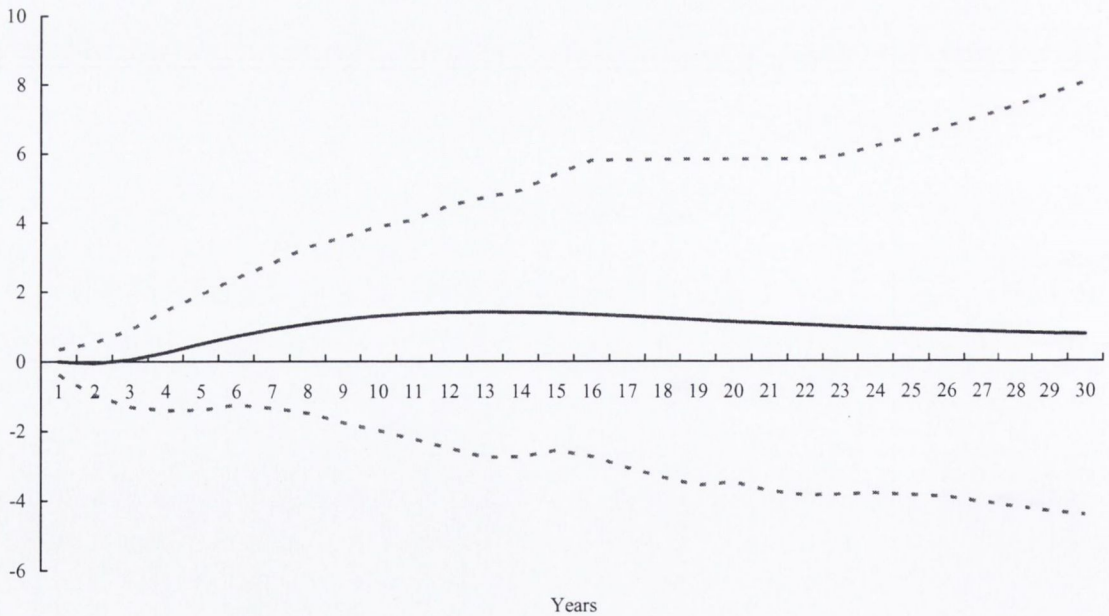


Chart 3.3pa Portugal - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

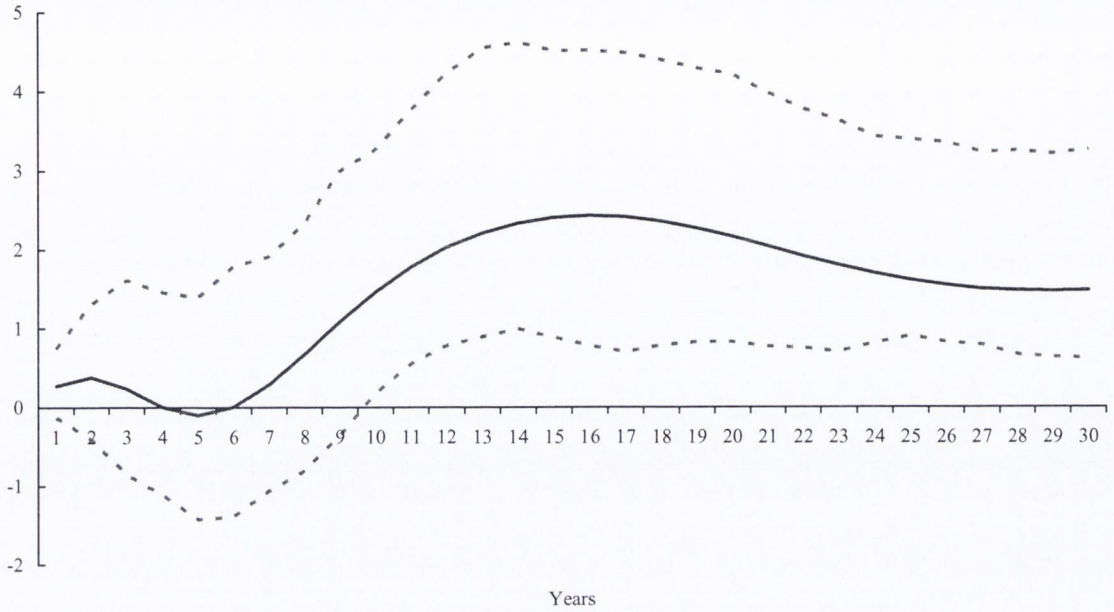


Chart 3.3pb Portugal - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

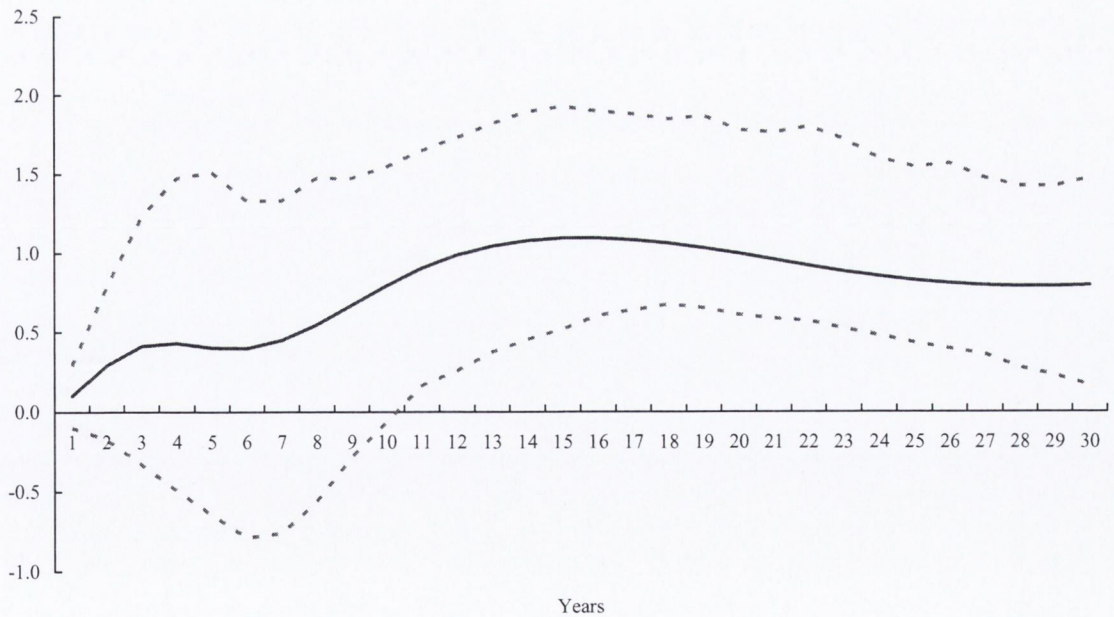


Chart 3.3qa Spain - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

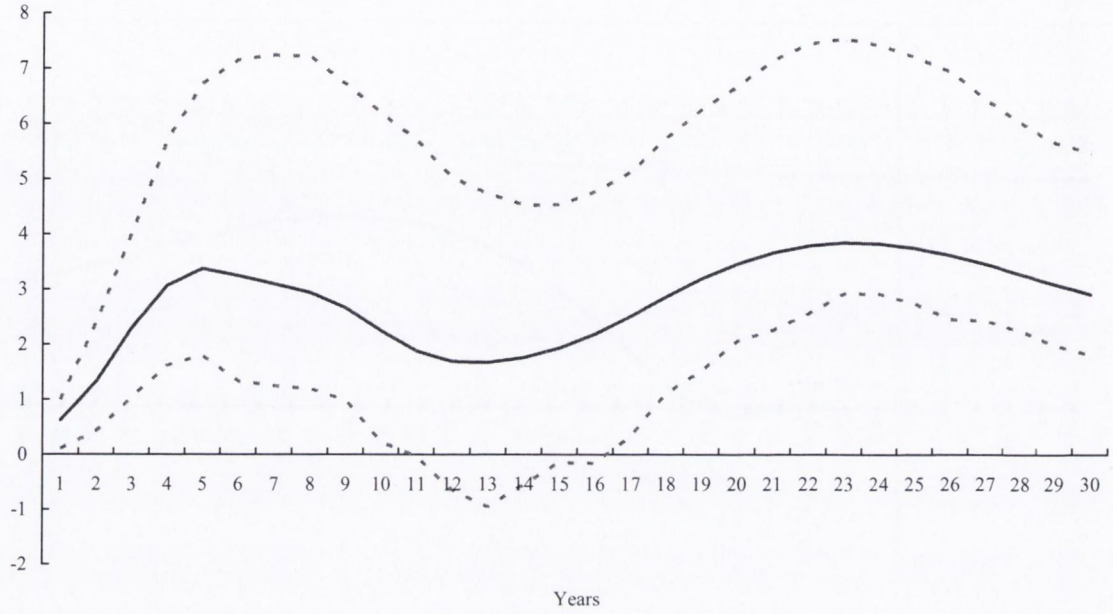


Chart 3.3qb Spain - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

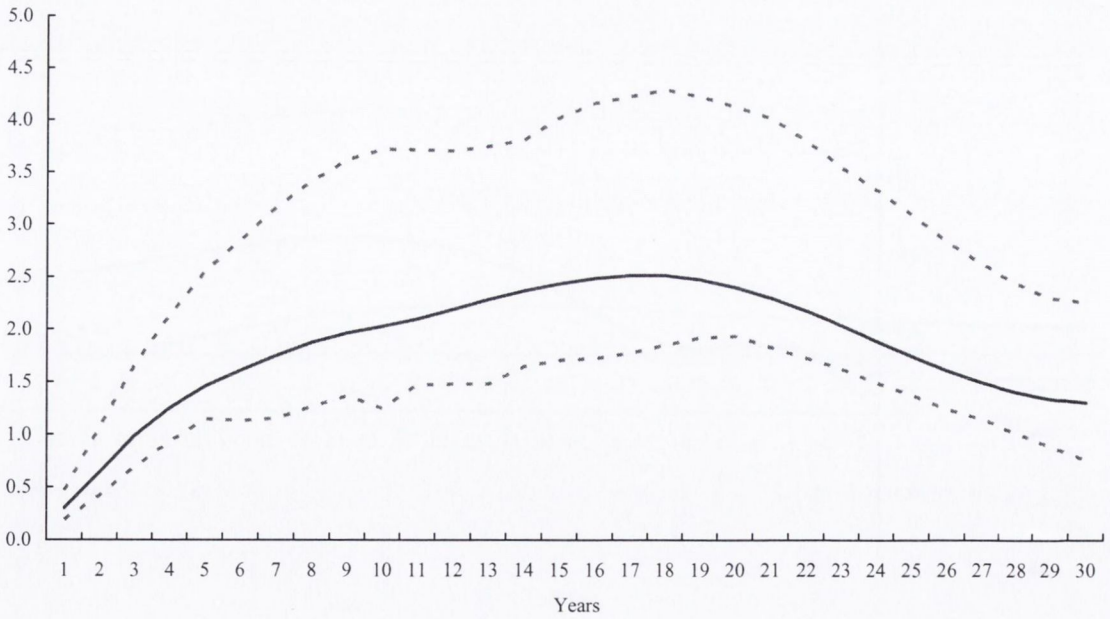


Chart 3.3ra Sweden - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

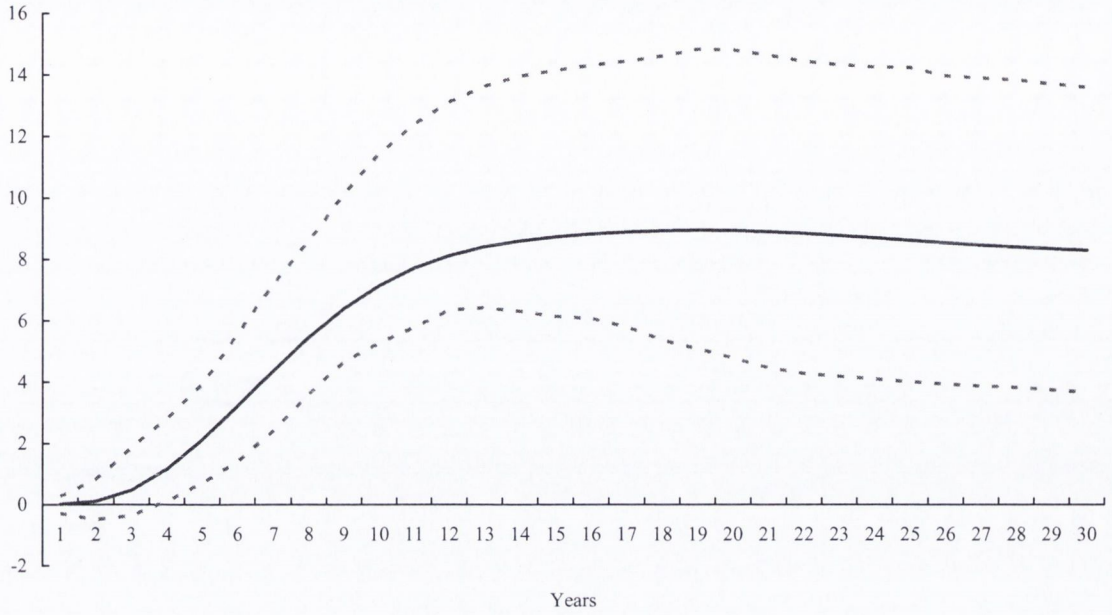


Chart 3.3rb Sweden - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

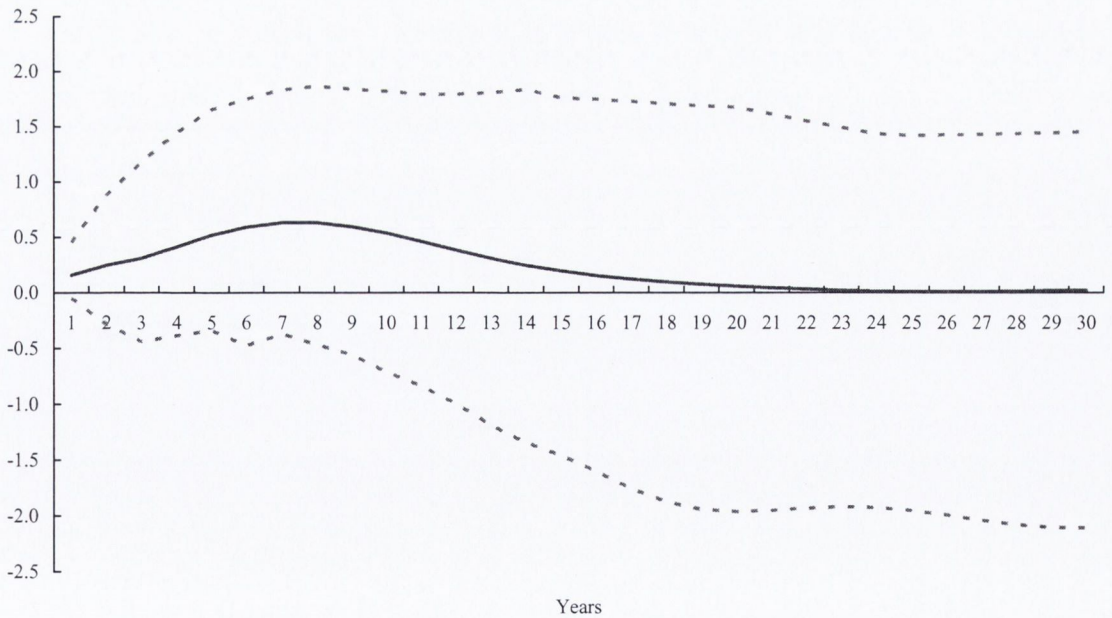


Chart 3.3sa UK - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

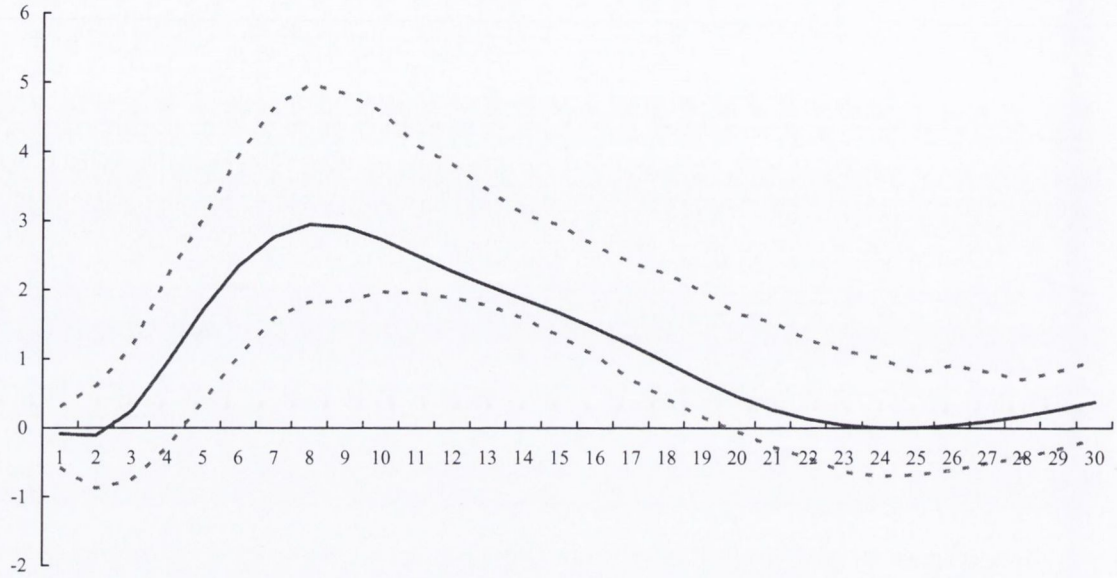


Chart 3.3sb UK - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

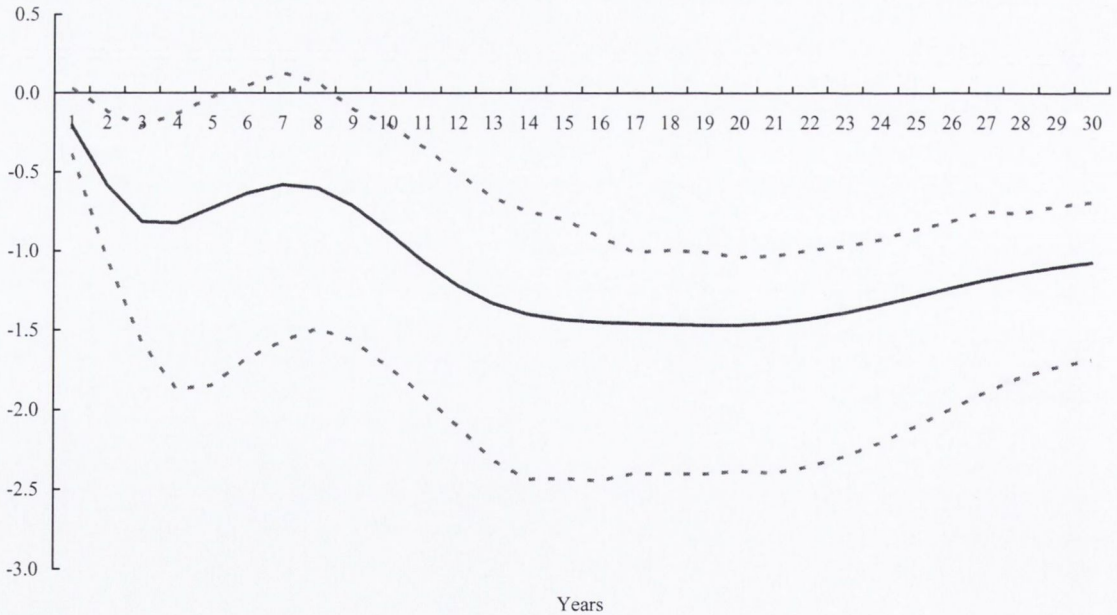


Chart 3.3ta USA - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

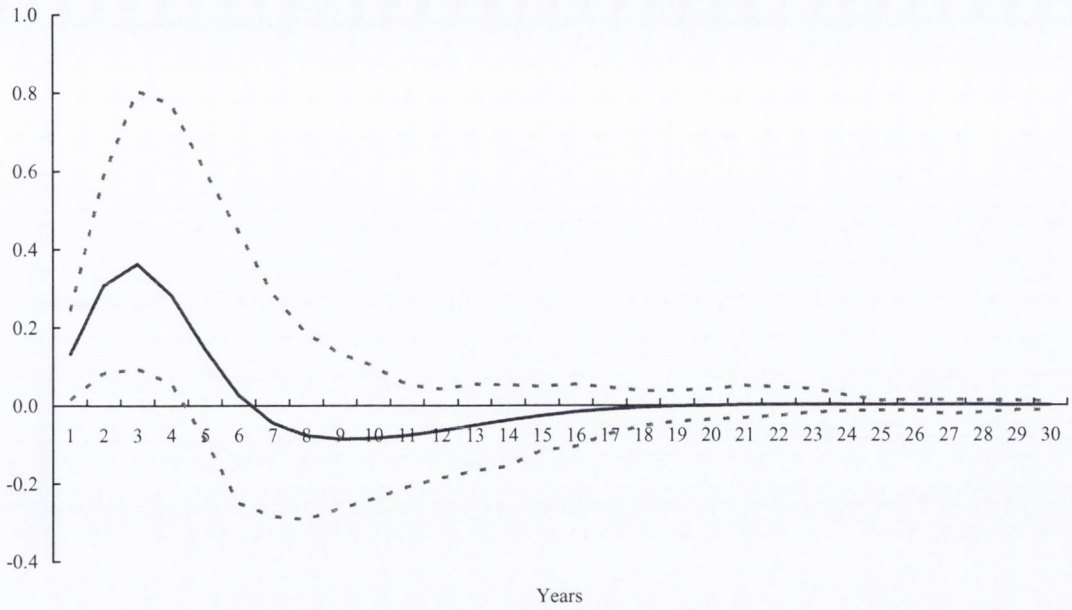


Chart 3.3tb USA - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

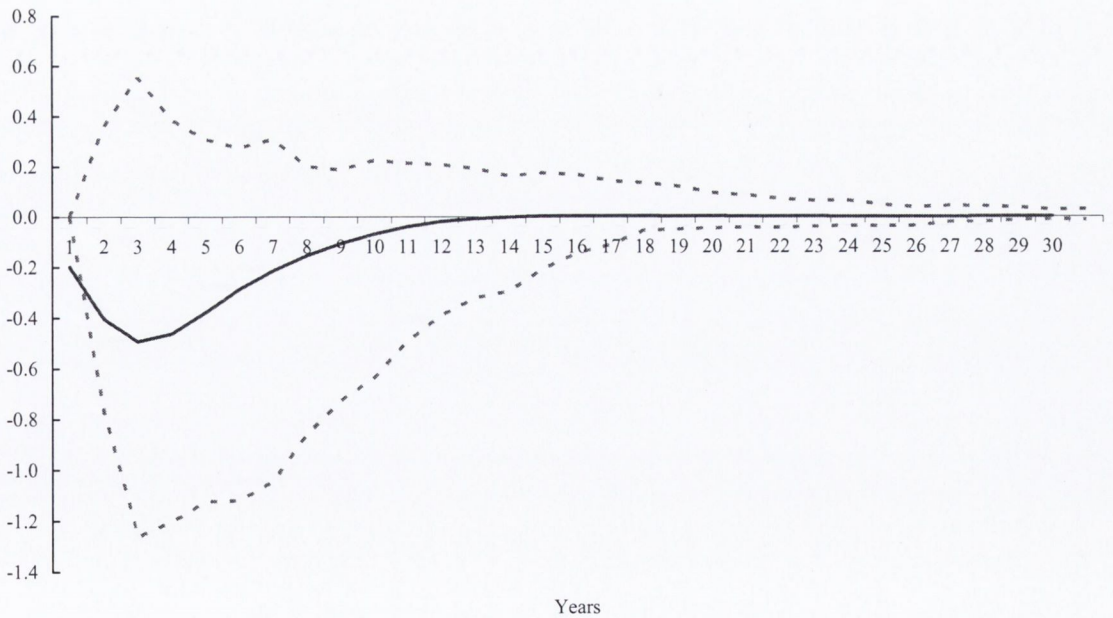


Table 3.1a: Testing for Cointegration at Pool level ($gk = \alpha + \beta pk$)

	gk	pk	RES
Levin, Lin and Chu t-test	1.31	1.86	0.14
	(0.90)	(0.85)	(0.56)
ADF-Fisher Chi Square test	33.30	36.53	29.47
Denmark	(0.76)	(0.72)	(0.89)

Notes: *The values quoted relate to the Levin, Lin and Chu t-test and the ADF-Fisher Chi Square test. The null hypothesis is that a unit root is present, p values are in parentheses. gk is the log of the public capital stock, pk is the log of the private capital stock.*

Table 3.1b: Testing for Cointegration at Country level ($gk = \alpha + \beta pk$)

	ERS	Ng-Perron		ERS	Ng-Perron
USA*	8.12	-3.12	Sweden	6.30	-5.36
UK	1.39	-12.18	Canada	4.93	-17.17
Austria	0.10	-2166.22	Japan	1.27	-18.98
Belgium	0.25	-113.45	Finland *	5.54	-1.29
Denmark	3.81	-10.87	Greece*	6.92	-3.33
France	4.89	-7.92	Ireland	0.86	-23.58
Germany	1.03	-24.64	Portugal	2.58	-12.12
Italy	0.29	-96.35	Spain	0.21	-14.02
Netherlands	8.16	-8.56	Australia	5.06	-7.16
Norway	4.31	-6.76	New Zealand	4.89	-6.25
Critical Values					
1%	1.87	-13.80			
5%	2.97	-8.10			
10%	3.91	-5.70			

Notes: *gk is the log of the public capital stock, pk is the log of the private capital stock. ERS refers to the Elliott-Rothenberg-Stock Optimal Unit Root Test and Ng-Perron refers to the Ng-Perron Modified Unit Root Test. For countries marked *, the null hypothesis (no cointegration) cannot be rejected at the 10% level.*

Table 3.2: Dynamic OLS (-2,2) Estimated Coefficients ($gk = \alpha + \beta pk$)					
	θ	β		θ	β
USA	13.74	0.59	Sweden	0.01	1.39
	(16.61)	(29.36)		(22.59)	(57.93)
UK	27.94	0.33	Canada	2.59	0.64
	(7.91)	(6.57)		(11.56)	(57.61)
Austria	1.17	0.74	Japan	1.82	0.89
	(0.62)	(20.16)		(5.67)	(131.31)
Belgium	0.02	1.41	*Finland*	0.01	1.48
	(2.96)	(7.02)		(9.23)	(18.03)
Denmark	37.34	0.34	*Greece*	0.14	1.04
	(1.19)	(0.90)		(0.06)	(0.19)
France	0.73	0.84	Ireland	1.92	0.55
	(3.15)	(71.75)		(1.02)	(5.02)
Germany	0.08	1.14	Portugal	0.02	1.40
	(6.54)	(22.33)		(1.02)	(2.08)
Italy	0.04	1.21	Spain	0.03	1.27
	(5.02)	(16.11)		(5.79)	(14.61)
Netherlands	3.60	0.59	Australia	1.57	0.66
	(0.91)	(3.08)		(5.96)	(86.34)
Norway	0.04	1.12	New Zealand	0.66	0.97
	(4.03)	(12.79)		(0.63)	(6.59)

Notes: *gk is the log of the public capital stock, pk is the log of the private capital stock. DOLS is run using a one period AR process. Adjusted t values are in parentheses. Countries in italics are those countries where the null hypothesis of no cointegration could not be rejected.*

Table 3.3: VECM Output - Private and Public Capital Stocks (2 lags)

		C	ECM	Δgk_{t-1}	Δpk_{t-1}	Δgk_{t-2}	Δpk_{t-2}	RBAR2	F
Austria	Δgk	0.001	-0.013	1.03***	0.05	0.03	-0.12	0.94	136.3
		(0.04)	(1.30)	(6.13)	(0.26)	(0.13)	(0.69)		
	Δpk	0.01	-0.008	-0.01	0.79	0.15	-0.20	0.96	181.18
		(2.98)	(0.91)	(0.04)	(4.71)	(0.89)	(1.33)		
Denmark	Δgk	-0.001	-0.024***	0.97***	-0.05	-0.03	0.04	0.96	181.2
		(0.54)	(3.02)	(5.20)	(0.42)	(0.18)	(0.31)		
	Δpk	0.007	-0.011	0.15	0.83***	-0.04	-0.18	0.71	21.0
		(2.18)	(0.92)	(0.52)	(4.52)	(0.13)	(0.98)		
Canada	Δgk	0.008	-0.03	0.95***	0.11	-0.15	-0.13	0.64	15.5
		(1.77)	(1.64)	(5.76)	(1.00)	(0.85)	(1.28)		
	Δpk	0.018	0.026	-0.42*	0.96***	0.12	-0.23	0.75	25.5
		(2.86)	(1.17)	(1.75)	(6.03)	(0.45)	(1.63)		
Australia	Δgk	0.004	-0.046***	0.99***	0.25*	-0.13	-0.10	0.85	45.1
		(0.09)	(2.83)	(6.30)	(1.75)	(0.80)	(0.71)		
	Δpk	0.019	-0.004	-0.04	0.87***	-0.18	-0.43***	0.51	9.3
		(3.92)	(0.25)	(0.28)	(5.81)	(1.07)	(2.75)		

Notes: *ECM is the Error Correction Mechanism estimated from the DOLS regression, Dgk is the change in the log of the public capital stock, Dpk is the change in the log of the private capital stock, t values are presented in parentheses, ***, ** and * represent statistical significance at the 1%, 5% and 10% levels respectively.*

Table 3.4: VECM Output - Private and Public Capital Stocks (3 lags)

		C	ECM	Δgk_{t-1}	Δpk_{t-1}	Δgk_{t-2}	Δpk_{t-2}	Δgk_{t-3}	Δpk_{t-3}	RBAR2	F
UK	Δgk	-0.013	-0.06***	0.97***	-0.11	-0.43*	0.14	0.29*	0.20	0.92	63.3
		(2.88)	(4.32)	(5.97)	(0.47)	(1.81)	(0.43)	(1.81)	(0.88)		
	Δpk	0.01	-0.027**	-0.18	1.16***	0.08	-0.52**	0.15	0.04	0.79	21.5
		(1.73)	(2.66)	(1.49)	(6.71)	(0.47)	(2.11)	(1.28)	(0.21)		
Germany	Δgk	0.002	-0.018*	1.24***	-0.07	-0.44	0.05	0.17	-0.27	0.92	67.8
		(0.74)	(1.78)	(7.06)	(0.30)	(1.62)	(0.14)	(0.94)	(1.14)		
	Δpk	0.01	0.001	-0.01	1.28***	0.16	-0.75**	-0.17	0.24	0.70	13.9
		(2.16)	(0.05)	(0.06)	(7.12)	(0.71)	(2.80)	(1.16)	(1.27)		
Norway	Δgk	0.005	-0.01	0.97***	0.47***	-0.17	-0.29	0.02	-0.08	0.82	25.5
		(1.37)	(0.60)	(5.59)	(2.90)	(0.71)	(1.26)	(0.13)	(0.45)		
	Δpk	-0.001	0.03	0.09	0.95***	-0.10	-0.22	0.07	0.16	0.86	34.9
		(0.41)	(1.38)	(0.50)	(5.55)	(0.38)	(0.88)	(0.44)	(0.85)		
Sweden	Δgk	-0.003	-0.08***	0.84***	0.00	-0.16	-0.06	0.23	0.13	0.95	98.58
		(1.43)	(4.12)	(5.00)	(0.01)	(0.73)	(0.18)	(1.47)	(0.60)		
	Δpk	0.03	0.17	0.23	1.33***	-0.23	-0.54*	0.08	-0.03	0.85	33.8
		(1.84)	(0.99)	(1.63)	(7.51)	(1.31)	(1.84)	(0.62)	(0.19)		
Japan	Δgk	0.0004	-0.02	1.16***	-0.14	-0.29	0.61***	0.02	-0.39***	0.94	87.99
		(1.24)	(0.82)	(7.65)	(0.96)	(1.29)	(2.73)	(0.14)	(2.72)		
	Δpk	0.0002	0.058*	0.55***	1.24***	-0.44	-0.31	-0.02	-0.07	0.93	73.8
		(0.61)	(1.73)	(3.16)	(7.22)	(1.68)	(1.19)	(0.09)	(0.42)		
Portugal	Δgk	0.026	-0.04*	0.76***	0.21	-0.06	-0.46	-0.11	0.28	0.52	7.12
		(2.71)	(1.86)	(4.41)	(0.83)	(0.26)	(1.21)	(1.03)	(1.62)		
	Δpk	0.01	0.026*	0.07	1.24***	-0.03	-0.69***	0.07	-0.32	0.74	17.19
		(1.98)	(1.98)	(0.66)	(7.71)	(0.25)	(2.90)	(0.49)	(1.81)		
New Zealand	Δgk	-0.003	-0.02	0.89***	0.50***	0.02	-0.25	0.07	-0.32*	0.87	38.5
		(0.86)	(1.62)	(5.37)	(3.27)	(0.09)	(1.13)	(0.49)	(1.81)		
	Δpk	0.016	-0.02	0.20	0.75***	0.03	-0.40	-0.37	0.03	0.63	10.6
		(3.72)	(1.25)	(1.09)	(4.50)	(0.13)	(1.65)	(2.27)	(0.13)		

Notes: *ECM is the Error Correction Mechanism estimated from the DOLS regression, Δgk is the change in the log of the public capital stock, Δpk is the change in the log of the private capital stock, t values are presented in parentheses, ***, ** and * represent statistical significance at the 1%, 5% and 10% levels respectively.*

Table 3.5: VECM Output - Private and Public Capital Stocks (4 lags)

		C	ECM	Δgk_{t-1}	Δpk_{t-1}	Δgk_{t-2}	Δpk_{t-2}	Δgk_{t-3}	Δpk_{t-3}	Δgk_{t-4}	Δpk_{t-4}	RBAR2	F
Belgium	Δgk	-0.029	-0.026*	0.66***	-0.01	-0.09	0.66	0.13	-0.11	0.30	-0.04	0.94	61.6
		(3.84)	(1.95)	(3.77)	(0.03)	(0.45)	(1.79)	0.64	(0.28)	(1.67)	(0.14)		
	Δpk	0.013	-0.004	0.06	0.84***	0.14	0.08	-0.10	-0.25	-0.13	-0.16	0.73	12.2
		(2.72)	(0.44)	(0.54)	(4.56)	(1.04)	(0.35)	(0.74)	(0.99)	(1.11)	(0.83)		
France	Δgk	0.004	-0.02	1.14***	0.07	-0.48*	0.35	0.41	-0.37	-0.21	-0.03	0.88	31.3
		(2.15)	(0.60)	(6.23)	(0.47)	(1.75)	(1.39)	(1.55)	(1.39)	(1.09)	(0.16)		
	Δpk	0.0003	0.046	0.20	1.27***	-0.3	-0.32	0.23	-0.22	-0.07	0.13	0.90	39.7
		(0.14)	(1.15)	(0.92)	(6.69)	(0.90)	(1.04)	(0.70)	(0.68)	(0.29)	(0.59)		
Italy	Δgk	0.001	-0.10***	0.37**	0.37	0.46**	-0.61	0.01	0.59	-0.04	-0.66*	0.73	12.6
		(0.32)	(3.49)	(2.34)	(1.57)	(2.63)	(1.46)	(0.04)	(1.41)	(0.28)	(2.56)		
	Δpk	0.004	0.026	0.23**	1.36***	-0.16	-0.79**	-0.01	0.14	-0.08	0.27	0.79	17.3
		(1.63)	(1.26)	(2.02)	(8.01)	(1.30)	(2.64)	(0.06)	(0.46)	(0.76)	(1.46)		
Netherlands	Δgk	0.002	-0.074***	0.77***	-0.11	-0.29	0.12	0.37	0.11	0.06	-0.19	0.95	82.0
		(0.59)	(3.70)	(4.40)	(0.70)	(1.32)	(0.60)	(1.56)	(0.59)	(0.33)	(1.28)		
	Δpk	0.013	-0.017	-0.18	0.7***	0.63***	-0.14	-0.20	-0.05	0.08	-0.21	0.89	26.0
		(4.06)	(0.76)	(0.95)	(4.10)	(2.65)	(0.67)	(0.75)	(0.26)	(0.39)	(1.36)		
Ireland	Δgk	-0.02	-0.079***	0.80***	0.18*	-0.34	0.18	-0.18	-0.03	0.27*	0.21*	0.95	88.5
		(3.85)	(3.88)	(4.87)	(1.91)	(1.50)	(0.81)	(0.81)	(0.24)	(1.85)	(1.85)		
	Δpk	0.02	-0.124***	-0.15	0.69***	0.21	-0.08	-0.08	0.13	0.54*	-0.41*	0.78	15.8
		(1.81)	(3.23)	(0.50)	(3.80)	(0.49)	(0.20)	(0.20)	(0.53)	(1.95)	(1.93)		
Spain	Δgk	0.02	-0.041*	0.94***	0.56	-0.34	-0.74	0.26	0.82	-0.02	-0.78***	0.75	13.3
		(2.93)	(2.00)	(5.67)	(1.80)	(1.30)	(1.40)	(1.00)	(1.60)	(0.10)	(2.77)		
	Δpk	0.002	0.037***	0.25***	1.37***	-0.35**	-0.90***	0.24*	0.41	-0.21**	0.01	0.91	43.2
		(0.77)	(3.39)	(2.83)	(8.26)	(2.60)	(3.17)	(1.72)	(1.51)	(2.24)	(0.03)		

Notes: *ECM is the Error Correction Mechanism estimated from the DOLS regression, Δgk is the change in the log of the public capital stock. Δpk is the change in the log of the private capital stock, t values are presented in parentheses, ***, ** and * represent statistical significance at the 1%, 5% and 10% levels respectively.*

Table 3.6: VECM Output - Private and Public Capital Stocks (Ireland with alternative lags)

		C	ECM	Δgk_{t-1}	Δpk_{t-1}	Δgk_{t-2}	Δpk_{t-2}	Δgk_{t-3}	Δpk_{t-3}	RBAR2	F
Ireland	Δgk	-0.012	-0.04***	0.78***	0.26***	-0.15	0.13			0.95	140.15
		(3.37)	(2.76)	(4.87)	(2.81)	(1.08)	(1.16)				
	Δpk	0.01	-0.073**	-0.25	0.89***	0.35	-0.19			0.78	24.3
		(1.49)	(2.45)	(0.83)	(5.16)	(1.38)	(0.91)				
Ireland	Δgk	-0.01	-0.06***	0.84***	0.22**	-0.40*	0.17	0.21	-0.01	0.95	97.5
		(2.81)	(3.01)	(4.82)	(2.19)	(1.75)	(1.30)	(1.40)	(0.03)		
	Δpk	0.01	-0.09**	-0.10	0.79***	-0.11	-0.07	0.42	-0.12	0.75	17.46
		(1.25)	(2.71)	(0.30)	(4.30)	(0.27)	(0.28)	(1.51)	(0.54)		

Notes: *ECM is the Error Correction Mechanism estimated from the DOLS regression. Δgk is the change in the log of the public capital stock, Δpk is the change in the log of the private capital stock, t values are presented in parentheses, ***, ** and * represent statistical significance at the 1%, 5% and 10% levels respectively.*

Table 3.7: VAR Results

		C	Δgk_{t-1}	Δpk_{t-1}	Δgk_{t-2}	Δpk_{t-2}	Δgk_{t-3}	Δpk_{t-3}	RBAR2	F
USA	Δgk	0.00	1.60***	0.13	-0.79**	-0.07	0.10	-0.04	0.93	90.1
		(0.50)	(9.10)	(1.61)	(2.64)	(0.60)	(0.59)	(0.44)		
	Δpk	0.10	-0.15	1.24***	0.03	-0.72***	0.06	0.24	0.72	17.5
		(2.20)	(0.41)	(7.33)	(0.05)	(2.92)	(0.17)	(1.42)		
Finland	Δgk	0.00	0.20	0.29	0.02	0.58	0.11	-0.03	0.65	12.9
		(0.57)	(1.14)	(0.49)	(0.08)	(0.68)	(0.65)	(0.05)		
	Δpk	0.00	0.36***	1.18***	-0.02	-0.57**	0.02	-0.13	0.94	97.9
		(0.06)	(7.30)	(7.01)	(0.32)	(2.31)	(0.29)	(0.76)		
Greece	Δgk	0.01	0.99***	-0.23	-0.36**	0.31**			0.55	13.1
		(2.43)	(5.65)	(1.55)	(2.07)	(2.16)				
	Δpk	0.00	0.17	0.90***	-0.04	-0.12			0.69	23.7
		0.52	(0.75)	(4.70)	(0.18)	(0.65)				

Notes: *Δgk is the change in the log of the public capital stock, Δpk is the change in the log of the private capital stock, t values are presented in parentheses, ***, ** and * represent statistical significance at the 1%, 5% and 10% levels respectively.*

Table 3.8: ECM Coefficients

	Public	Private		Public	Private
Austria	-0.013	-0.008	Portugal	-0.040	0.026
	(0.20)	(0.37)		(0.07)	(0.06)
Denmark	-0.024	-0.011	New Zealand	-0.020	-0.016
	(0.00)	(0.37)		(0.11)	(0.22)
Canada	-0.030	0.026	Belgium	-0.026	-0.004
	(0.11)	(0.25)		(0.06)	(0.66)
Australia	-0.046	-0.004	France	-0.020	0.046
	(0.01)	(0.81)		(0.55)	(0.26)
UK	-0.060	-0.027	Italy	-0.100	0.026
	(0.00)	(0.01)		(0.00)	(0.22)
Germany	-0.018	0.001	Netherlands	-0.074	-0.017
	(0.08)	(0.96)		(0.01)	(0.81)
Norway	-0.014	0.033	Ireland	-0.079	-0.124
	(0.55)	(0.18)		(0.00)	(0.00)
Sweden	-0.080	0.170	Spain	-0.041	0.037
	(0.00)	(0.33)		(0.05)	(0.00)
Japan	-0.024	0.058			
	(0.42)	(0.09)			

Notes: *p values are presented in parentheses*

Table 3.9: Relative Capital Imbalances

	1960	2003	Average		1960	2003	Average
Austria	-3.03%	-3.50%	0.17%	Portugal	0.73%	-0.74%	-0.75%
Denmark	-8.97%	-2.53%	-1.53%	New Zealand	-12.13%	-15.95%	-8.31%
Canada	-1.17%	1.30%	0.79%	Belgium	-6.90%	-12.66%	-7.71%
Australia	-0.62%	0.17%	0.42%	**France**	0.73%	1.13%	0.85%
UK	-8.76%	-2.05%	-2.72%	Italy	-1.64%	-2.12%	-1.88%
Germany	-6.91%	-8.11%	-4.55%	Netherlands	-5.08%	-0.87%	-0.63%
Norway	1.33%	1.33%	0.45%	Ireland	-4.54%	-1.61%	-1.21%
Sweden	-2.43%	-1.13%	-0.83%	**Spain**	2.84%	1.87%	2.18%
Japan	-0.59%	-0.21%	0.30%				

Notes *Imbalances are calculated using the long-run relationship (Equation 3.2) and the DOLS estimated values of θ and β. Relative imbalances are expressed as a percentage of the total capital stock. Imbalances arising due to a relative inadequacy of the public capital stock are signed negatively while those arising due to a relative inadequacy of the private capital stock are signed positively.*

Table 3.10: Speed of Convergence to Long-Run Equilibrium in Years							
	Public	**Private**	**Total**		**Public**	**Private**	**Total**
Austria	-3.38	1.00	1.41	Portugal	0.32	-0.05	-0.06
Denmark	40.23	-1.58	-1.65	New Zealand	7.00	-2.84	-4.78
Canada	-1.09	0.51	0.95	Belgium	10.76	-1.92	-2.33
Australia	-0.42	0.04	0.04	**France**	-1.00	0.20	0.24
UK	6.69	-0.57	-0.62	Italy	2.86	-0.63	-0.81
Germany	6.95	-1.43	-1.80	Netherlands	48.79	-1.88	-1.95
Norway	-1.17	0.15	0.17	Ireland	3.63	-0.80	-1.03
Sweden	0.38	-0.13	-0.19	**Spain**	-1.91	0.62	0.91
Japan	-1.41	1.26	0.67				

Notes *The speed of convergence for each was calculated using the half-life decay formula with the rate given by the average change in the public and private capital stocks expressed as a percentage of the average capital imbalance. Countries in bold have a relatively inadequate private capital stock on average.*

Chapter Four

Convexity in Aggregate Investment Costs: An Empirical Study

1960-2003

4.1 Introduction

The efficient accumulation of capital is pivotal to the long-term economic success of both the firm and the state. This tautology has provoked substantial research interest in optimal investment decision making with particular attention being paid to the role played by adjustment costs in influencing the appropriate pace at which capital imbalances should be eliminated. Clearly, the best interests of the firm and the state are served by an elimination of any capital imbalances as expeditiously as possible, consistent with moderate investment cost growth.

The need to balance speed with cost growth containment is a consequence of the neo-classical assumption of convexity in investment adjustment costs. However, there is evidence of non-convexities in adjustment costs at the firm level which would mean that optimal investment decision making would see investment imbalances being addressed as they arise rather than over an extended period. The presence of non-convexities in adjustment costs would imply that adjustment should be concentrated and rapid rather than dispersed and gradual. Clearly, appreciating the nature of adjustment costs is critical to the determination of efficient investment policies and their optimal implementation.

This chapter adds to existing research by exploring the convexity of total aggregate investment costs in twenty developed economies, by considering the convexity of government and private sector investment costs as well as that of construction and equipment investment costs. It seeks to draw conclusions to aid optimal investment decision making at both the state and firm level.

The profit-maximising firm will seek to invest to the point where the marginal cost of investment is equal to its marginal revenue. Governments will not necessarily abide by such an investment rule. Given that the marginal benefit of public investment sees the economic benefits of investment (marginal revenue) being enhanced by positive externalities of an environmental, social and not least political nature, governments face a broader set of motivations than the firm in making investment decisions. This chapter seeks to investigate whether the different investment rules affect the relation between the level of investment and relative cost of investment as measured by investment deflators in both the public and private sectors. Second, it investigates the nature of the relation between incremental investment and the cost of investment in total, government, private-sector, construction and equipment investment. Third, it considers

the relative convexity of government and private investment costs and finally the relative convexity of equipment and construction costs. The chapter proceeds as follows: Section 4.2 presents a short review of the literature; section 4.3 discusses data considerations; the methodology used in the chapter is presented in section 4.4; our empirical results are outlined and discussed in section 4.5; while section 4.6 concludes.

4.2 Literature Review

Under the neo-classical theory of capital, the rational firm will choose a capital stock to maximise the present value of all future cash flows. However, the adjustment to such an optimal capital stock is not instantaneous and is influenced by the level and nature of the costs of adjustment.

Eisner and Strotz (1963) and Lucas (1967) assumed that the cost of adjustment is a function of net investment. If this function is convex, that is if the average economic price of capital goods is greater for higher levels of net investment, the rational, profit-maximising firm will adjust gradually to the deviation of the capital stock from its optimal level. Essentially, the presence of strictly convex adjustment costs predicts that the rational firm's planned response to a change in the optimal capital stock will take the form of a distributed lag. Eisner and Strotz argue that convexity arises due to the impact of higher demand for investment goods on the price of investment goods as well as due to the escalating costs associated with the integration of new equipment. Their work has been influential and the theoretical literature on investment demand has relied heavily on the assumed presence of symmetric convex adjustment costs.

Changes in the capital stock can be modeled as follows:

$$K_t - K_{t-1} = (1-\mu_t)(K_t^* - K_{t-1}) \tag{4.1}$$

where K_t is the capital stock at time t,
K_t^* is the optimal capital stock and
$(1-\mu_t)$ is the speed of adjustment.

The greater the level of μ_t, the greater the level of adjustment costs and the longer the adjustment to the optimal capital stock level.

Rothschild (1971) raises some scepticism about the merits of the convexity assumption, suggesting that the first argument above is weak and that the second is merely an assertion. He believes that there is no reason to believe that the cost of adjustment function is necessarily either convex or concave. Some firm's functions may be initially concave reflecting increasing returns to scale and later convex driven by the cost of disruption as large-scale projects become increasingly complex. If the cost of adjustment function is concave or indeed linear, the optimal policy for the rational firm would see the response to a change in the desired capital stock being concentrated in one period.

While the imposition of an assumption of convex adjustment costs is widespread in the empirical literature, Hamermesh and Pfann (1996) note that "the few studies of investment demand that permit examining alternative cost structures uniformly find that adjustment is not characterized by symmetric quadratic costs". The empirical evidence in favour of the standard neo-classical model with convex costs of adjustment is weak with Caballero (1999) reporting a poor performance at the aggregate level in the case of firms. He notes that there is ample evidence at a plant level of a non-linear relationship between investment and fundamentals with investment behaviour characterised by periods of inactivity as well as investment spikes. Plants exhibit periods of inactivity as well as large investment bursts but there is scant evidence of negative investment. A model with convex costs will not predict such bursts of investment and inaction.

Barnett and Sakellaris (1998) suggest that the results of their empirical analysis of regions of insensitivity and regions of responsiveness to Tobin's Q imply that adjustment costs may not be quadratic but that the most likely cause is not a firm's inability to disinvest but rather its reluctance to make large changes. Cooper and Haltiwanger (2006) show that, in the absence of profitability shocks, the plant will follow an optimal replacement policy where it replaces capital only if it has been depreciated to a critical level. Relative to the partial adjustment of the convex adjustment cost model, the model with non-convex adjustment costs provides an incentive for the firm to overshoot its target and to allow depreciation to reduce the capital stock over time. They show that a model with only convex costs cannot generate the bursts of investment and bouts of inactivity observed at the plant level and that both the non-convex and irreversibility models are able to produce relationships between investment and fundamentals which are much closer to the empirical evidence.

Nilsen and Schiantarelli (2003) in a study of Norwegian plants and firms report strong evidence in support of the importance of irreversibilities and non-convexities at the micro level although these measures add little explanatory power in relation to aggregate investment. Caballero and Engel (1999) postulate that a firm's adjustment policies take the form of a probability of adjustment, which they refer to as an adjustment hazard, which responds to changes in a firm's capacity gap. They show that the passivity of normal times is occasionally more than offset by what they describe as a brisk response to large current or accumulated shocks. The adjustment hazards are non-constant with a significant range of inaction and increase sharply thereafter. They show that these non-linearities improve the aggregate performance of dynamic investment equations while Hamermesh and Pfann (1996) note that temporal aggregation will bias results towards inferring that factor demand adjusts smoothly.

Dixit and Pindyck (1994) distinguish between firm level investment decisions and aggregate investment observations. Different firms have different decision thresholds and the same aggregate shock may push some firms over the threshold but not others. As a consequence, the effect of a shock on aggregate investment will be spread over time even though the action of each firm is concentrated at a point in time. Consequently, lumpiness is less likely to be a feature of adjustment at the aggregate level.

Abel and Eberly (1994), Doms and Dunne (1998) and Caballero, Engel and Haltiwanger (1995) argue that non-convexities and irreversibilities can significantly improve the performance of aggregate investment models. Doms and Dunne, in a study of over 13,700 manufacturing plants, find that many plants undergo large investment episodes although there is a large variation across plants in their capital accumulation patterns. They note that the frequency distribution of investment in US manufacturing plants appears inconsistent with the assumption of smooth adjustment. Caballero, Engel and Haltiwanger find that the relation between actual and mandated (or the difference between the current and optimal capital stocks) investment is highly non-linear. If mandated investment is negative, firms do not quickly adjust their capital stocks downward. If mandated investment is positive but small, the response level is weak. However, if mandated investment is large and positive, firms adjust their capital stocks rapidly. They conclude that a kinked adjustment model with a zone of inaction best describes the data. Models including non-convexities and irreversibilities predict investment patterns which are significantly closer to empirical experience. Ito, Bresnahan and Greenstein (1999), in a detailed study of the nature of adjustment costs

for specific technologies conclude that there are convex and non-convex elements present.

Hall (2004) estimates adjustment costs for labour and capital from the Euler equations for factor demand using annual data from two-digit industries. He finds relatively strong evidence against substantial adjustment costs and also finds that the likely biases from aggregation over time and aggregation over firms are relatively small. He concludes that this finding implies that transitory rents from factor adjustment are not an important source of variation in the market value of firms.

The existing body of empirical research in this area has concentrated on microeconomic adjustment using plant or industry-level data. At a macroeconomic level, convexity is not a prevalent underlying assumption in modelling investment costs. Richardson (1988) in a paper on the OECD's Interlink model reports that prices are generally modelled as a mark-up on costs. For the major economies, the domestic price equations entail the linking of individual expenditure deflators to the business value-added deflator, determined on the basis of production-function measures of the factor mix, factor costs and competitor prices. For the smaller countries, consumer prices and other expenditure deflators are determined as a mark-up on labour and other costs, allowing for trend developments in productivity. In general, the mark-up process used in the Interlink model is variable, reflecting fluctuations in produce market conditions as measured by the "gap" between actual output and an exogenous measure of potential output. The equations for private-sector wage earnings are generally in the form of an orthodox expectations-augmented Phillips curve. The unemployment rate is used as a proxy for excess demand in the labour market with the specific choice between linear, log-linear and inverse functional forms.

For Ireland, Bradley and Fitzgerald (1988) report that in the Economic and Social Research Institute's economic model, the analysis of capital formation proposals involve the standard methods of neo-classical investment theory. Investment adjustment costs are assumed to be convex. Brayton and Tinsley (1996) note that in the standard adjustment cost specification, costs associated with changing prices are proportional to the squared deviation of the current price from last period's price. However, they report that in the basic paradigm in the FRB/US model of adjustment dynamics, a generalization of the standard adjustment cost specification is employed which contains three sets of regressors: a single regressor consisting of the distance to the equilibrium that remains at the start of the current quarter; a second set of regressors

consisting of lags of the dependent variable; and a third set of regressors containing expected future changes in the desired equilibrium price. In discussing this model, Brayton et al (1997) note that higher-order adjustment costs in the price and wage equations are present as indicated by significant lagged dependent variables. They also state that the standard linear-quadratic model of adjustment costs frequently does a poor job in characterizing the dynamic behaviour of macroeconomic variables. In relation to the European Central Bank's structural macroeconomic model, Fagan et al (2001) state that the investment deflator is in the long run a weighted average of the GDP deflator at factor cost and the import deflator. In the short run, ECM terms are included in the investment deflator equation. The GDP deflator at factor cost is estimated using trend unit labour costs and the import deflator.

This chapter adds to the existing body of work by considering the convexity of total, pan-economy investment costs as well as the convexity of government and private investment and construction and equipment investment.

4.3 Data Considerations

The dataset used in this chapter extends from 1960 to 2003. Government investment deflators, total investment deflators and GDP deflators are taken from the OECD quantitative database. Private Investment deflators are extrapolated from the OECD-sourced public and total investment deflators as follows:

$$PI = I - GI \tag{4.2}$$

$$NomPI = NomI - NomGI \tag{4.3}$$

$$NomI = I * IP \tag{4.4}$$

$$NomGI = GI * GIP \tag{4.5}$$

$$PIP = NomPI / PI \tag{4.6}$$

where PI is real Private Investment (unknown)
I is real total Investment (known),
GI is real Public Investment (known)
Nom refers to nominal values

IP is the total investment deflator index (known)

GIP is the Public investment deflator index (known)

and PIP is the Private investment deflator index (unknown)

In some cases, the data series does not run fully back to 1960: Denmark (1971), Canada (1961), France (1963), Ireland (1970), New Zealand (1962), Norway (1962) and UK (1963). Equipment and construction data are taken from the European Commission's AMECO database. Trade data used in the construction of a series of instrumental variables are taken from the IMF's Direction of Trade database.

In arriving at our estimates for capital stocks, we have assumed that public capital assets depreciate by 4% per annum, that non-residential private assets depreciate by 8% per annum, while residential private assets depreciate by 1.5% per annum. The private asset depreciation rate for each country is calculated by reference to the split in residential/non-residential asset values in the base year. The estimated values of the public and private capital stocks are generated by the following expression:

$$K_{t+1} = (1-\delta)^t K_1 + \sum_{i=0}^{t-1} (1-\delta)^i I_{t-i} \tag{4.7}$$

where K_t is the real capital stock at the beginning of period t

I_t is real gross investment in period t

and δ is a geometric depreciation rate.

Following the methodology employed by Jacob, Sharma and Grabowski (1997) and Kamps (2004), due to the absence of official stock data, estimates of the initial capital stock for 1960 are generated by the construction of an artificial investment series for the 1860-1959 period. This series is built on the assumption that gross investment increased by 4% across the twenty countries considered in this chapter, a level comparable to the average growth rate from 1960.

4.4 Methodology

4.4.1 Model Specification

This chapter seeks to address the issue of whether investment costs, at the total, sectoral or type levels are convex. It considers whether such costs are symmetrically or

asymmetrically convex. This allows us to discern if there are different impacts on investment costs of periods of positive investment activity and disinvestment. The shape of the adjustment cost function has important implications for the scale of investment plans, the pace of implementation and the relative role of the private and public sectors in their delivery.

In contrast to previous work, this chapter is not seeking to explain investment behaviour using various forms of cost function. Rather, it seeks to investigate whether convexity is a feature of investment costs at aggregate levels. To explore the issue of convexity of investment costs, we performed the regressions listed below. First, we consider a simple relation. Equation (4.8) investigates the convexity of total investment adjustment costs by regressing the difference between a measure of investment inflation and overall inflation in the economy on a measure of investment growth and its square term. A priori, α_1 is expected to be positive in all cases with the possible exception of equipment investment cost growth due to the impact of increasing international trade openness. A positively-signed α_2 will indicate that the relation between cost growth and activity is convex.

$$\Delta Ip_t - \Delta GDPp_t = \alpha_0 + \alpha_1 \Delta(I_t / K_{t-1}) + \alpha_2((I_t / K_{t-1})^2 - (I_{t-1} / K_{t-2})^2) + \varepsilon_t \qquad (4.8)$$

where Δ is the first difference operator

Ip is the log of the investment deflator index

GDPp is the log of the GDP deflator index

I is total investment

K is the total capital stock

and ε_t is a stochastic error term.

In order to allow for possible asymmetry in convexity, equation (4.9) builds on the relation presented in equation (4.8) by introducing dummy variables to isolate the impacts of investment growth when its direction is positive and negative.

$$\Delta Ip_t - \Delta GDPp_t = \alpha_0 + \alpha_1\gamma_1\Delta(I_t / K_{t-1}) + \alpha_2\gamma_2\Delta(I_t / K_{t-1}) + \alpha_3\gamma_1((I_t / K_{t-1})^2 - (I_{t-1} / K_{t-2})^2) + \alpha_4\gamma_2((I_t / K_{t-1})^2 - (I_{t-1} / K_{t-2})^2) + \varepsilon_t \qquad (4.9)$$

where the variables are as described above, and

$\gamma 1$ is a dummy variable with a value of 1 when the relevant variable is positive

$\gamma 2$ is a dummy variable with a value of 1 when the relevant variable is negative.

Having considered the convexity of total investment, we distinguish between overall investment by source, both government and private sector. We examine the convexity of government investment costs in the following regressions where the difference between a measure of cost growth in government investment and in the overall economy provides the dependent variables:

$$\Delta GIp_t - \Delta GDPp_t = \alpha_0 + \alpha_1 \Delta(GI_t / GK_{t-1}) + \alpha_2((GI_t / GK_{t-1})^2 - (GI_{t-1} / GK_{t-2})^2) + \varepsilon_t \quad (4.10)$$

where Δ is the first difference operator
GIp is the log of the government investment deflator index
GDPp is the log of the GDP deflator index
GI is government investment
GK is the government capital stock
and ε_t is a stochastic error term.

Equation (4.11) builds on the simple relation presented in equation (4.10) by including dummy variables which allow the behaviours of government investment costs to be considered separately during periods of growth and of contraction in real government investment activity.

$$\begin{aligned}\Delta GIp_t - \Delta GDPp_t &= \alpha_0 + \alpha_1\gamma_1 \Delta(GI_t / GK_{t-1}) + \alpha_2\gamma_2 \Delta(GI_t / GK_{t-1}) \\ &+ \alpha_3\gamma_1((GI_t / GK_{t-1})^2 - (GI_{t-1} / GK_{t-2})^2) + \alpha_4\gamma_2((GI_t / GK_{t-1})^2 - (GI_{t-1} / GK_{t-2})^2) + \varepsilon_t\end{aligned} \quad (4.11)$$

The chapter then proceeds by considering the convexity of non-government or private sector investment in the following regressions:

$$\Delta PIp_t - \Delta GDPp_t = \alpha_0 + \alpha_1 \Delta(PI_t / PK_{t-1}) + \alpha_2((PI_t / PK_{t-1})^2 - (PI_{t-1} / PK_{t-2})^2) + \varepsilon_t \quad (4.12)$$

where Δ is the first difference operator
PIp is the log of the private investment deflator index
GDPp is the log of the GDP deflator index
PI is private investment
PK is the private capital stock
and ε_t is a stochastic error term.

Equation (4.13) expands on equation (4.12) by allowing for possible asymmetric behaviours in investment costs through the introduction of another set of dummy

variables which, again, separate periods of growth and of contraction in real investment activity, in this instance in the private sector.

$$\begin{aligned}\Delta PIp_t - \Delta GDPp_t &= \alpha_0 + \alpha_1\gamma_1\Delta(PI_t / PK_{t-1}) + \alpha_2\gamma_2\Delta(PI_t / PK_{t-1}) \\ \Delta PIp_t - \Delta GDPp_t &= \alpha_0 + \alpha_1\gamma_1\Delta(PI_t / PK_{t-1}) + \alpha_2\gamma_2\Delta(PI_t / PK_{t-1}) \\ &\quad + \varepsilon_t \\ +\alpha_3\gamma_1((PI_t / PK_{t-1})^2 - (PI_{t-1} / PK_{t-2})^2) &+ \alpha_4\gamma_2((PI_t / PK_{t-1})^2 - (PI_{t-1} / PK_{t-2})^2) + \varepsilon_t\end{aligned} \tag{4.13}$$

We then consider the issue of convexity of investment costs by type of investment, that is construction and equipment investment. In equation (4.14), the difference of construction investment cost growth and overall cost growth in the economy is the dependent variable with construction investment activity and its square term providing the independent variables.

$$\Delta CONp_t - \Delta GDPp_t = \alpha_0 + \alpha_1\Delta(CONi_t) + \alpha_2((CONi_t)^2 - (CONi_{t-1})^2) + \varepsilon_t \tag{4.14}$$

where Δ is the first difference operator
CONp is the log of the construction investment deflator index
GDPp is the log of the GDP deflator index
CONi is the log of real construction investment
and ε_t is a stochastic error term.

The impact of possible asymmetries is considered through the addition of dummy variables as presented in Equation (4.15).

$$\begin{aligned}\Delta CONp_t - \Delta GDPp_t &= \alpha_0 + \alpha_1\gamma_1(\Delta CONi_t) + \alpha_2\gamma_2(\Delta CONi_t) \\ +\alpha_3\gamma_1(CONi_t^2 - CONi_{t-1}^2) &+ \alpha_4\gamma_2(CONi_t^2 - CONi_{t-1}^2) + \varepsilon_t\end{aligned} \tag{4.15}$$

Similar regressions were performed as outlined in equations (4.16) and (4.17) with the difference between cost growth in equipment investment and the overall economy providing the regressand and measures of real activity in equipment investment providing the regressors.

$$\Delta EQp_t - \Delta GDPp_t = \alpha_0 + \alpha_1\Delta(EQi_t) + \alpha_2((EQi_t)^2 - (EQi_{t-1})^2) + \varepsilon_t \tag{4.16}$$

where Δ is the first difference operator
EQp is the log of the equipment investment deflator index
GDPp is the log of the GDP deflator index
EQi is the log of real equipment investment
and ε_t is a stochastic error term.

Equation (4.17) augments equation (4.16) through the inclusion of dummy variables to isolate periods of positive and negative momentum in real equipment investment.

$$\begin{aligned}&\Delta EQp_t - \Delta GDPp_t = \alpha_0 + \alpha_1\gamma_1(\Delta EQi_t) + \alpha_2\gamma_2(\Delta EQi_t) \\ &+\alpha_3\gamma_1(EQi_t^2 - EQi_{t-1}^2) + \alpha_4\gamma_2(EQi_t^2 - EQi_{t-1}^2) + \varepsilon_t\end{aligned} \tag{4.17}$$

We then turn to examine the nature of the relation between government and private investment costs and relative changes in their respective investment levels.

$$\begin{aligned}&\Delta GIp_t - \Delta PIp_t = \alpha_0 + \alpha_1(\Delta(GI_t / GK_{t-1}) - \Delta(PI_t / PK_{t-1})) \\ &+\alpha_2((GI_t / GK_{t-1} - PI_t / PK_{t-1})^2 - \\ &(GI_{t-1} / GK_{t-2} - PI_{t-1} / PK_{t-2})^2) + \varepsilon_t\end{aligned} \tag{4.18}$$

where Δ is the first difference operator
GIp is the log of the government investment deflator index
PIp is the log of the private investment deflator index
GI is government investment
GK is the government capital stock
PI is private investment
PK is the private capital stock
and ε_t is a stochastic error term.

Equation (4.18) considers the convexity of government and private investment by regressing relative cost growth on relative investment growth and its square term.

$$\begin{aligned}&\Delta GIp_t - \Delta PIp_t = \alpha_0 + \alpha_1\gamma_1(\Delta(GI_t / GK_{t-1}) - \Delta(PI_t / PK_{t-1})) \\ &+\alpha_2\gamma_2(\Delta(GI_t / GK_{t-1}) - \Delta(PI_t / PK_{t-1})) \\ &+\alpha_3\gamma_1((GI_t / GK_{t-1} - PI_t / PK_{t-1})^2 - (GI_{t-1} / GK_{t-2} - PI_{t-1} / PK_{t-2})^2) \\ &+\alpha_4\gamma_2((GI_t / GK_{t-1} - PI_t / PK_{t-1})^2 - (GI_{t-1} / GK_{t-2} - PI_{t-1} / PK_{t-2})^2) + \varepsilon_t\end{aligned} \tag{4.19}$$

Equation (4.19) builds on the simple, symmetric relation expressed in equation (4.18) through the inclusion of dummy variables to isolate asymmetry effects.

Finally, we examine the convexity of construction investment relative to equipment investment. This can be considered as an examination of the convexity of the non-traded sector relative to the traded sector of the economy. Given the influence of international conditions on the cost of traded goods, *a priori* we would expect equipment investment costs to be less likely to exhibit a convex relation with actual equipment investment at least during expansionary periods. We first consider a simple

model, presented in equation (4.20), relating construction and equipment costs to activity levels and its square term.

$$\Delta CONp_t - \Delta EQp_t = \alpha_0 + \alpha_1(\Delta CONi_t - \Delta EQi_t) + \alpha_2((CONi_t - EQi_t)^2 - (CONi_{t-1} - EQi_{t-1})^2) + \varepsilon_t \quad (4.20)$$

where Δ is the first difference operator
CONp is the log of the construction investment deflator index
EQp is the log of the equipment investment deflator index
CONi is the log of real construction investment
EQi is the log of real equipment investment
and ε_t is a stochastic error term.

We also consider the following relation, equation (4.21), which allows us to examine possible asymmetries in the relation between deflators and the level of construction and equipment investment through the inclusion of dummy variables.

$$\Delta CONp_t - \Delta EQp_t = \alpha_0 + \alpha_1\gamma_1(\Delta CONi_t - \Delta EQi_t) + \alpha_2\gamma_2(\Delta CONi_t - \Delta EQi_t) + \alpha_3\gamma_1((CONi_t - EQi_t)^2 - (CONi_{t-1} - EQi_{t-1})^2) + \alpha_4\gamma_2((CONi_t - EQi_t)^2 - (CONi_{t-1} - EQi_{t-1})^2) + \varepsilon_t \quad (4.21)$$

4.4.2 Estimation Issues

The regressions discussed above were estimated using Ordinary Least Squares with Newey-West heteroscedasticity and autocorrelation consistent standard errors. First, pooled regressions were run for each of the equations outlined while second, the equations were estimated on a country-by-country basis. Where required due to the presence of autocorrelation, first-order autoregressive terms were included in the relevant regressions.

In addition, due to the possibility that investment growth itself is endogenous to the level of investment inflation, Two-Stage Least Squares (TSLS) regressions were also run. The instrumental variables for each country's various investment growth variables were the weighted average of the relevant investment growth terms amongst the other 19 countries considered in this chapter. The weights used were the proportion of total trade between each country and the other 19 considered here over the 1980-2005 period. This weighting was chosen on the grounds that business cycles are correlated across

countries, particularly so in the case of the business cycles of trading partners (See Imbs (2004)), and investment activity should be subject to the same influence. The strength of the instruments was ascertained by regressing the change in the capital stock variable ($\Delta(I_t/K_{t-1})$) on its trade-weighted equivalents. The coefficient (0.63) was highly significant with a t-statistic of 10.73 and an adjusted R^2 of 0.21, allowing us to conclude that the instruments are strong. In a regression including both the potentially endogenous variable and its instrument, the instruments are not statistically significant which suggests that the approach taken is valid.

The TSLS procedure corrects for possible correlation between the independent variables and the stochastic error term due to the endogeneity of the independent variable. The estimators obtained by the process are consistent. However, the estimators converge to their true values only as the sample size increases indefinitely and the procedure is statistically justified in large samples such as those included in our panel regressions.

4.5 Empirical Analysis

4.5.1 Data Description

Each of the deflator indices considered in this chapter are presented graphically in Charts 4.1a to 4.1t. A visual inspection generates some initial, interesting observations. The cumulative GDP deflator exceeds that of investment in the great majority of countries considered in this chapter with 16 of the 20 countries covered showing a higher deflator index at the end of the period of the study. The exceptions are Finland, Greece and Ireland where the total investment deflator index exceeds the GDP deflator index and Germany where the index readings in 2003 are approximately equivalent. There is also a marked contrast between the cumulative increases in the deflator indices across the group of countries with the most modest increases reported in Germany in the case of GDP and Japan in the case of total investment while the largest cumulative increases were recorded in Greece. In general, we can make the observation that within the group of countries considered, overall economic costs increased faster on average over the period 1960 to 2003 than investment costs.

Turning to the sectoral indices, there is less uniformity across the group when comparing government and private sector investment deflators. The cumulative growth in the average government deflator is greater in ten countries, lower in eight while the deflators are approximately equivalent in New Zealand. Separate sector deflator indices

are not available for Portugal. As a consequence, we can only make the mild observation that government deflators were only slightly more likely on average to be greater than private investment deflators in the OECD members and in the period considered.

Ejarque and McKnight (2006) report that a key fact to have emerged from US National Income and Product Accounts is that the price of equipment investment goods has fallen dramatically in the past 30 years relative to the price of consumption non-durables and services. A visual inspection of the deflator index charts for equipment and construction investment strongly point to a continuing fall in the cost of equipment investment relative to the cost of construction investment over the past four decades in the OECD area. In the case of sixteen of the seventeen countries for which construction and equipment investment deflator data are available, construction investment costs were higher over the period with the one exception being Norway which experienced a surge in equipment costs in the mid-1980s. Even in that one case, there has been a convergent movement in costs since the early 1990s.

4.5.2 Empirical Results

4.5.2.1 Unit Root Tests

Turning to the substantive issues addressed in this chapter, Table 4.1 presents the results of pool unit root tests for each of the pool regressors and regressands using both Levin, Lin and Chu t and ADF-Fisher Chi Square Tests. The former test assumes a common unit root process while the latter assumes individual unit root processes. In all cases, the null hypothesis that a unit root is present can be rejected.

At the country level, Tables 4.2a and 4.2b present the result of tests for the presence of unit roots in the regressors and regressands respectively using the Elliot-Rothenberg-Stock method. In relation to the regressands, the null hypothesis of non-stationarity cannot be rejected in the case of Austria for the total, government and private investment cost variables, in the cases of Austria, and Italy where we are considering government investment costs relative to private investment costs and Austria and Ireland in the case of construction investment costs relative to equipment investment costs. For the regressors, the null hypothesis of non-stationarity cannot be rejected in the case of Finland and Japan where government investment activity relative to private investment activity is the independent variable. In discussing the results of the

individual regressions, the results of the stationarity tests are taken into account and highlighted.

4.5.2.2 Results from Panel Regressions

The results of the pooled regressions where the difference between the total investment deflator and the GDP deflator is the dependent variable are presented in Table 4.3a. Taking the results of the symmetric equations, both OLS and TSLS regression results point to concavity in total investment costs with the squared activity term being negatively-signed and statistically significant at the 1% level in both cases. The linear activity term is statistically significant at the 1% level under OLS and is significant at the 5% level in the case of the TSLS regression. With the significant linear coefficients positively-signed, we can draw the conclusion that there is a positive relation between relative investment cost growth and investment activity which decelerates as investment activity gains momentum. This initial finding that investment costs are concave is offered support with the addition of fixed cross section effects, the results of which are presented in Table 4.3b.

The inclusion of asymmetric activity effects generates some interesting results. Under OLS, the linear activity term is positively-signed and statistically significant during real investment contractions as shown in column (3) of Tables 4.3a and 4.3b. Moreover, with the squared activity term being both negatively signed and statistically significant but only during periods of investment contraction, the evidence from the asymmetric regression is supportive of the hypothesis that overall investment cost growth is concave. The results show that investment cost growth declines relative to overall cost growth during periods of falling investment and that the rate of decline decelerates as the pace of investment decline increases. However, the lack of statistically significant relations between investment costs and positive investment activity suggests that investment costs are concave but only in one direction. That is, there is a positive and concave relation between investment cost growth and investment activity growth but it is limited to periods when investment activity growth is negative. This result has some intuitive appeal. Periods of falling investment activity are likely to occur alongside more general economic weakness that will translate into an easing of pricing pressures, most clearly in areas not susceptible to sticky price behaviours.

The strength of this conclusion is reinforced by the results of the asymmetric TSLS regressions with confirmation offered of the sign and significance of the coefficients

generated by OLS and discussed above. Overall, no support is offered for the view that there is a relation between increased investment activity and increased investment costs. At the aggregate investment level, the evidence suggests that economic agents can proceed with their investment plans without cause for concern about the impact of such activity on the cost of investment. Furthermore, it is worth noting that the adjusted "goodness of fit" reading of 11% suggests that the relative price behaviour of investment is subject to a wider range of influences than simply the pace of investment activity.

Tables 4.4a and 4.4b present the pooled regression results where the difference between government and overall investment inflation is the regressand and a measure of investment growth (the rate of growth in the government investment/government capital stock ratio) and a square term provide the regressors. The results, with the linear and square terms in the symmetric regressions statistically insignificant, suggest that government relative investment costs are non-responsive to government investment activity. Further support for this conclusion is offered by the asymmetric OLS regressions with the terms again being statistically insignificant during both periods of investment expansion and contraction. However, the possible impact of endogeneity on this conclusion is highlighted by the results of the TSLS asymmetric regression where the linear term during periods of investment expansion is negatively signed and significant at the 10% level as shown in Table 4.4a. This offers some support for the view that government investment enjoys diminishing marginal costs. However, the results present no evidence in support of the view that there is a convex relation between cost and activity in government investment. Convexity in government investment costs was not a feature of the nineteen countries considered in this analysis over the period from 1960 to 2003.

Next, the analysis turns to the other investment source, the private sector. As with the conclusions in relation to total investment, the results, presented in Tables 4.5a and 4.5b suggest that private investment costs are concave to private investment activity. The linear term is statistically significant and positive in both of the symmetric regressions pointing to the presence of a positive linear relation between the cost of private investment relative to overall costs as measured by the GDP deflator. However, with the square term negatively signed and statistically significant in the OLS and TSLS regressions both with and without fixed cross section effects, the results suggest that the rate of increase in cost growth falls as activity increases. That is, there is a concave relation between private investment costs and private investment activity.

Allowing for the presence of asymmetries, the OLS results suggest that this concave relation exists only during periods of investment contraction and that private investment cost growth is non-responsive to private investment activity growth during investment expansions. However, while the TSLS results report that the square term is negative and significant at the 5% level and the linear term is positive and approaches significance at the 10% level during periods of contracting private investment activity, they also introduce evidence of a positive linear relation between activity and costs. Even in this case, while the coefficient is positively signed during periods of investment expansion, the square term is again negatively signed suggesting that the relation is again concave rather than convex. Our analysis suggests that increased private investment does not lead to accelerating private investment cost growth.

Having considered the issue of convexity by investment source, we analyse the issue by investment type, that is in terms of construction investment and equipment investment. The results are presented in Tables 4.6a and 4.6b. *A priori*, one would expect construction investment to exhibit a greater tendency to convexity given its labour-intensive nature and its relatively limited exposure to international competitive pressures. Taking the results of the symmetric regressions, the linear coefficient is positively signed and statistically significant as expected but only in the case of the TSLS regression, and only at the 10% level, where fixed cross section effects are not included. Allowing for the impact of possible endogeneity in the OLS regression, we have evidence that construction investment cost growth increases as construction investment activity increases. However, with the square terms in the symmetric regressions being statistically insignificant, we can initially conclude that there is no evidence of convexity in construction investment costs. However, the introduction of asymmetric effects clouds this conclusion.

The OLS and TSLS regressions with asymmetric effects offer somewhat conflicting evidence of convexity with the former regressions returning no statistically significant coefficients. Taking the OLS results, the results suggest that construction investment costs are not responsive to investment activity. The TSLS results suggest that there is a relation between construction investment costs and activity during investment contractions. The combination of the negatively-signed linear term and positively-signed square term during periods of falling investment activity suggest that investment costs increase as investment activity falls but do so at a diminishing rate. The only evidence of a convex relation is presented in the TSLS regression where the square term is positively signed during investment expansions suggesting that higher levels of

increased investment activity have an escalating impact on costs. However, the quality of this evidence is impaired by the lack of statistical significance in the fixed cross section effects regression and in either regression where the linear term is concerned.

The results of these regressions with investment costs increasing as activity falls raise some issues in relation to causality. It may well be the case that rather than investment costs being impacted by investment activity that the opposite may apply in relation to construction investment. That is, that agents are reluctant to invest during periods of high construction cost growth. This observation has some intuitive value given the scale and cost of construction investments. In any event, the panel construction investment regressions are noteworthy once again for the absence of any evidence of a convex relation between relative cost growth and activity levels, with the exception of the TSLS results.

Given the evolution of equipment investment costs noted earlier and the impact of technology and international trade on price levels in traded goods, it can be seen that equipment investment costs have declined over time as equipment investment activity has increased. Consequently, one would expect, *ex ante*, that the strongest evidence of negative convexity in costs, that is that cost growth declines at an accelerating rate as investment activity increases, would be reported during periods of expanding equipment investment. The results of the symmetric OLS regression, reported in Tables 4.7a and 4.7b, offer some support for this expectation with the linear term being negatively signed and significant at the 1% level. The symmetric square term is significant and negatively signed suggesting that the pace of decline accelerates as investment activity changes. This suggests that there is a convex and negative relation between costs and activity in equipment investment. However, the strength of the conclusion is impaired by the results of the symmetric TSLS regression, which is distinguished by the absence of statistically-significant coefficients.

The results of the asymmetric regressions are presented in Tables 4.7a and 4.7b. There is no evidence of a linear relation between costs and activity during periods of investment expansion. However, there is evidence at the 1% level of a negative linear relation between equipment investment and cost growth during periods of investment contractions. The results of the asymmetric OLS regressions suggest that relative cost growth in equipment investment increases as activity falls pointing once again to issues of causality. Again, the evidence generated fails to support the view that equipment investment cost growth is convex during periods of investment expansion with the

square term in the asymmetric regression negatively signed and significant at the 10% level during such periods. These observations are underlined by the magnitude of the adjusted R^2 readings of 0.23 for the symmetric and 0.31 for the asymmetric regressions.

Having considered the behaviour of various types of investment cost growth relative to the GDP deflator, the analysis proceeds by considering the relative convexity of government and private investment and the relative convexity of construction and equipment investment. Tables 4.8a and 4.8b report the results of the regressions where the difference between government and private sector investment cost growth is the dependent variable and the difference between government and private sector investment activity and its square term provide the independent variables. The linear term under symmetric OLS is negatively signed and statistically significant suggesting that both types of investment cost growth relative to the other investment cost growth type fall as each respective activity level changes. That is, government investment cost growth falls relative to private investment cost growth when government investment activity is relatively increasing and private investment cost growth falls relative to government investment cost growth when private investment activity is relatively increasing.

The output of the asymmetric regressions suggests that this effect is limited to the case where government activity is falling relative to private sector investment activity with the relevant linear term (that is, where the dummy variable is negative) being statistically significant and negative in both OLS regressions. These results are not confirmed in the TSLS regressions and, given the impact of possible endogeneity, it would be unsafe to draw firm conclusions. There is no evidence of relative positive convexity during periods of relative government investment growth. However, with the square term being statistically significant and negatively signed during periods of relative government investment growth only, the results suggest that relative government investment costs decrease at an accelerating rate as relative government activity increases. This observation is underlined when account is taken of the negatively-signed linear term which is approaching significance at the 10% level with a t-statistic reading of 1.62 during periods of relatively expanding government investment. The firmest possible conclusion from these results is that government investment cost growth rates are more likely to fall relative to private sector investment cost growth rates during periods when government investment is outpacing private-sector investment.

The final set of panel regressions, those disaggregated into construction and equipment investment, are presented in Tables 4.9a and 4.9b. The results of the symmetric regressions are, at first glance, counterintuitive with the linear terms in both regressions being negatively signed and strongly significant (1% level). This result suggests that construction investment cost growth moderates relative to that of equipment as relative construction activity increases. However, alternatively, the same result can be interpreted as meaning that equipment investment costs fall relatively as relative equipment investment increases. Intuitively, this is a more plausible conclusion. Its veracity can best be ascertained by considering the results of the asymmetric regressions. Here, the linear term in all regressions (OLS and TSLS, with and without fixed cross section effects) is negatively signed and statistically significant at the 1% level during periods of relative equipment investment growth suggesting that equipment investment cost growth falls on a relative basis when equipment investment is growing relative to construction investment. The same conclusion can be drawn in relation to relative construction costs given the presence of a negatively-signed linear coefficient when construction investment is relatively expanding. However, it is worth highlighting the possible impact of reverse causality here with this result being potentially driven by the impact of rising costs on equipment investment.

The presence of a positive and significant coefficient on the square term when construction investment momentum is relatively positive suggests that relative construction investment costs decline at a diminishing rate as investment activity increases. This result allows us to observe that on a relative basis, construction investment cost growth accelerates as construction investment activity increases relative to equipment investment activity. That is, construction investment costs are more convex than equipment investment costs.

At the pool level, it is clear that the only convincing evidence of convexity in investment costs is presented by the construction sector and only relative to equipment investment. For both total and private investment, cost growth actually declines, albeit at a diminishing pace, as investment falls. Government investment cost growth is non-responsive to government investment activity. Potential reverse causality issues arise in relation to construction and equipment investment with evidence presented that prices actually increase during periods of declining activity. In order to explore whether these relations are universal or limited to certain countries, we performed the same series of regressions on a country level.

4.5.2.3 Results from Country-by-Country Regressions

Tables 4.10 to 4.13 detail the nature of the relation between total investment cost growth relative to growth in overall GDP costs and the change in the total capital stock. First-order autoregressive variables are also included where the presence of autocorrelation is indicated by Durbin-Watson test results. Evidence of convexity is scant with only the United States reporting a statistically-significant positive square term in the symmetric regression. Furthermore, it reports a significant linear term that is negatively signed suggesting that investment cost growth declines at a diminishing pace relative to overall cost growth as investment activity increases. This result highlighting the concavity of total investment costs in the United States is confirmed by the results of a TSLS regression.

For three countries, Canada, France and Ireland, there is strong evidence that while investment cost growth relative to overall economic cost growth increases as activity increases, it does so at a diminishing rate with the linear terms positively signed and the square terms negatively signed. This result is only confirmed in the case of Ireland when account is taken of the TSLS regression output. The results for Austria are excluded from consideration owing to non-stationarity issues as discussed earlier.

Taking account of asymmetries, investment cost growth is more responsive to declining investment activity with the linear term statistically significant and positively signed in nine countries (seven under TSLS) during investment contractions while it is positively signed and statistically significant in only two countries during investment expansions. This supports the observation from the panel data results that investment costs are more responsive to declining investment activity with results for a considerable number of countries showing prices responding in the logical way to an investment contraction. Evidence of potential convexity is limited to four countries during investment expansions and one country during investment contractions. However, in all five cases, a positively signed square term is accompanied by a negatively signed linear term suggesting that, while cost growth increases at an accelerating pace as activity increases, it is reversing negative momentum at more moderate levels of activity. In France and Canada, there is a concave relation between costs and activity with the linear term positive and the square term negative during expansionary periods, all terms being statistically significant at the 10% and 1% levels respectively. In eight of the nine countries where a positive linear coefficient was returned during investment

contractions, the related square term is significant and negatively signed again suggesting the existence of a concave relation.

We cannot conclude that there is evidence of convexity at a country-by-country level in total investment costs. The most striking results generated in these regressions indicate that, in the greater number of countries, investment costs are more responsive to declines in activity, that they follow logic and decline in response to such momentum and that the rate of that decline diminishes as the negative momentum accelerates.

The results of the country-by-country analysis of the convexity of government investment costs are presented in Tables 4.14 to 4.17. While the presence of statistically significant linear terms is confined to seven countries in the symmetric (OLS) analysis, in two of these countries, Denmark and Sweden, the term is signed negatively showing that government investment cost growth relative to overall cost growth is inversely related to government investment activity. In the other countries, namely Belgium, Finland, France, Italy and Norway, the square term is negative, thus pointing to concavity in government investment costs. The TSLS results offer support for these findings in the cases of Denmark, Italy and Norway.

Taking account of the impact of asymmetries, the evidence again points to concave relations. Ireland is the only country with a positive linear relation between cost and activity during periods of investment expansion by government but the square terms is negative. Belgium, Canada and Italy report that government investment costs decline as investment activity declines but again, the negative related square term points to concavity. This result is only confirmed in the case of Belgium when account is taken of the output of the TSLS regressions. Potential causality issues are highlighted in Denmark, Spain and Sweden where there is an inverse relation between investment costs and activity declines. The overall conclusion to be drawn from this particular analysis is that government investment costs are not convex with the most striking evidence showing that, where a relation can be shown to exist between government investment costs and activity, it is most likely to be a concave one.

The results of the analysis where relative cost growth in private investment is the variable of interest are presented in Tables 4.18 to 4.21. Taking the symmetric regression results first, there is no evidence of convexity. Taking the OLS and TSLS outputs, Ireland is the only country where we can assert there is a positive relation between private investment activity and relative private investment cost growth

although this relation is concave. The results of the asymmetric regression are more fruitful in seven of the countries considered. However, in no country do we find evidence of positive convexity (that is positive and significant linear and square terms). Again, there is more likely to be a positive relation between cost and activity during investment declines with the OLS results highlighting such outturns in five countries. This result is only confirmed for Finland when the TSLS method is used. It is worth remarking on the strength of the result for the United States where the adjusted R^2 reading stands at 0.51. However, potential causality issues are highlighted here with the combined OLS and TSLS results suggesting that private investment costs rise on a relative basis during investment contractions. Overall, the evidence from the country-by-country regressions strongly supports the panel finding that there is no evidence of convexity in private investment.

In relation to construction investment, the evidence presented in Tables 4.22 to 4.25 suggests that symmetric convexity of cost growth relative to GDP cost growth is not a widespread feature in the seventeen countries considered in these particular regressions. There is evidence of a positive relation between cost and activity in the symmetric analysis in one country, Germany, and here that linear relation is not accompanied by a similarly signed and significant square term. In the majority of countries returning a significant linear coefficient, that is in seven of the eight countries, that coefficient is negative, suggesting an inverse relation between activity and cost in construction investment. In all cases where the linear term is statistically significant, the square term is also significant but carries the opposite sign. However, these results are not robust with only Ireland reporting a statistically-significant coefficient in the TSLS regressions. In that case, the square term is significant at the 5% and is positively signed suggesting that there is a convex dimension to construction investment costs in Ireland. However, taking the results of the OLS and TSLS regressions together, the most noteworthy results suggest that relative cost growth declines at a diminishing rate as construction investment increases. This is counter-intuitive given the relatively closed and sheltered nature of the construction sector.

In fact, there is no evidence when asymmetric effects are included in the OLS regression of a positive relation between cost growth and activity during investment expansions. All statistically significant linear coefficients are negatively signed suggesting that construction investment costs have an inverse relation with construction activity. Again, issues of potential reverse causality arise during periods of investment contractions. These concerns are diminished by the TSLS results with statistical

significance only arising during investment contractions and with the coefficients negatively signed in only one of four cases. Ireland is the only country to return a positive and statistically-significant coefficient on the square term in both regressions during investment expansions. Moreover, with the linear term negative but insignificant in this instance, this evidence suggests that investment costs are related convexly to investment activity in Irish construction. However, taken together, the results suggest that construction costs are unresponsive to construction activity across most countries in general and across all countries during investment expansions. The convexity indications are peculiar to Ireland. This result is not wholly unexpected given the pace of construction investment activity in Ireland in the latter part of the period under consideration.

Tables 4.26 to 4.29 present the results of the regressions where relative equipment cost growth is the dependent variable. The symmetric output suggests that equipment costs are generally non-responsive to activity with Belgium and Norway the only countries reporting statistically significant coefficients in both OLS and TSLS regressions. In neither instance is there evidence of convexity.

When asymmetric effects are included, the results suggest that a relation between activity and cost growth is more likely to arise during investment contractions with ten of the seventeen countries considered reporting statistically significant linear coefficients. Moreover, with the coefficient on the linear term negatively signed in six of the nine instances in the OLS regressions (and all four in the TSLS regressions), issues of potential reverse causality again arise during equipment investment contractions. Both France and Norway report a negatively-signed coefficient on the square term during investment contractions, supporting the view that equipment investment costs diminish as investment activity increases.

Moving to the relative sectoral level, results of the country-by-country regressions where the difference between government and private sector investment inflation is the regressand are presented in Tables 4.30 to 4.33. Setting aside the Austrian, Finnish, Italian and Japanese results due to the possible presence of a unit root in the variables, the symmetric results suggest that relative government and private investment costs are non-responsive to relative activity differences in most countries. The exception is the United Kingdom where the negatively-signed and significant linear term suggests that government investment cost growth moderates relative to private sector investment cost growth as activity increases relative to private sector investment activity and that it

increases on the same relative basis as relative government investment activity falls. However, these findings are not robust given the results of the TSLS regression.

The asymmetric analysis points to the presence of relative convexity in only two countries, Canada and Denmark where both the linear and square terms are negatively signed. In the case of Canada, the results show that government investment costs are negatively convex, that is they fall at an accelerating rate, to government investment activity relative to the private investment sector during periods when government investment is expanding relative to private investment. The opposite is the case in Denmark where private investment cost growth is negatively convex relative to government investment cost growth. That means that private investment costs decline at an accelerating pace on a relative basis as private investment increases. However, in neither instance can the results be judged robust given the absence of statistically-significant coefficients in the TSLS regressions for Canada and Denmark.

Finally, Tables 4.34 to 4.37 present the results of the regressions where the difference in cost growth between construction and equipment investment is the dependent variable and the difference in investment growth and its square term are the independent variables. Taking the symmetric results first, there is some evidence that relative construction costs are inversely related to relative construction activity with three of the four statistically-significant linear terms being negatively signed. In no case, does the square term point to convexity. However, these results could be equally interpreted to mean that equipment costs decline relative to construction costs during periods of relatively greater equipment investment in Belgium, Norway and the United Kingdom with the TSLS results offering support in the case of the latter two countries. The latter is a more plausible explanation and can be best examined through the addition of asymmetric effects.

When dummy variables are included to capture the impact of asymmetries, the results show there is a negative linear relation between relative activity and relative costs in four of the seven countries where statistically significant relations were found. In Denmark, France and Germany, there is the expected positive linear relation. However, negatively signed square terms point to concavity on a relative basis. The results of the TSLS regression are more intuitively appealing with six of the seven statistically-significant linear terms positively signed during relative construction expansions and all negatively signed during relative expansions by equipment investment. The evidence of these regressions suggests strongly that, on a relative basis, construction investment

costs rise during construction investment expansions while equipment investment costs decline during equipment investment expansions. This is intuitively appealing given the relative labour intensity and openness to trade of both sectors. However, in no instance is there evidence that such relations are convex.

4.6 Conclusions

The results presented in this chapter suggest that the neo-classical assumption that investment adjustment costs are convex has limited validity at the aggregate level. There is no evidence that aggregate investment costs accelerate as real investment expenditure growth becomes increasingly rapid in the OECD countries analysed as a unit. In fact, the analysis conducted shows that concavity at the total aggregate level arises during periods of disinvestment. This chapter presents similar results in relation to the private sector where investment costs decline at a diminishing rate during periods of investment contraction.

This result has some intuitive appeal. Periods of falling investment activity are likely to occur alongside more general economic weakness that will translate into an easing of pricing pressures, most clearly in areas not susceptible to sticky price behaviours. The evidence presented in this chapter suggests that a fall in investment activity at the aggregate level or in private investment will lead to an decelerating decline in investment cost growth.

The results present no evidence in support of the view that there is a convex relation between cost and activity in government investment. In fact, the evidence presented in this chapter suggests that government investment costs are non-responsive to changes in government investment activity. On a relative basis, we present results suggesting that construction investment costs rise during construction investment expansions while equipment investment costs decline during equipment investment expansions.

The chapter also raises issues about the causality of investment costs and activity in the construction and equipment sectors with the results suggesting that costs rise during periods of investment contraction. This is clearly counter-intuitive with this relation more likely to suggest that investment activity declines in response to rising investment costs.

This chapter does not offer empirical support for the theory that investment adjustment costs are universally convex. Rather it presents evidence that the relation between investment costs and activity is more likely to be concave and is most prevalent during periods of disinvestment at the aggregate level. From a policy perspective, there is a clear conclusion to be drawn. Concerns about the impact on price levels of an increase in investment activity should not be allowed to restrain investment where the deficit arises on foot of relatively insufficient government and equipment investment. It is only in relation to construction investment that caution should be exercised when planning large increases in activity due to evidence that there may be a positive relation between cost growth and activity levels as highlighted when they are considered relative to equipment investment.

Chart 4.1aa Australia Deflator Indices (log scale)

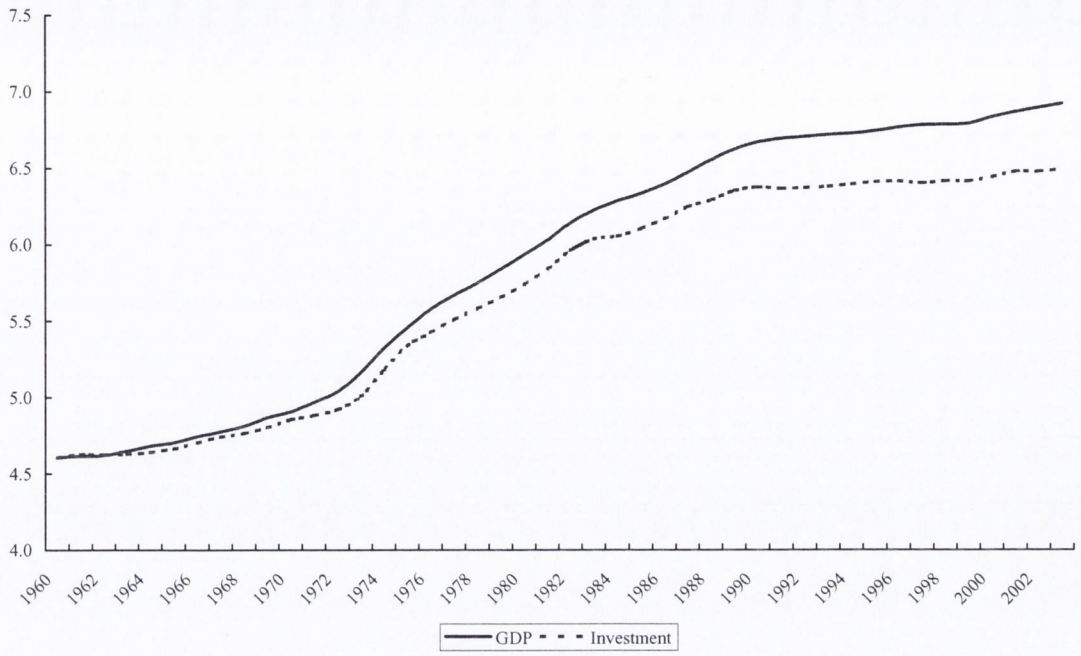


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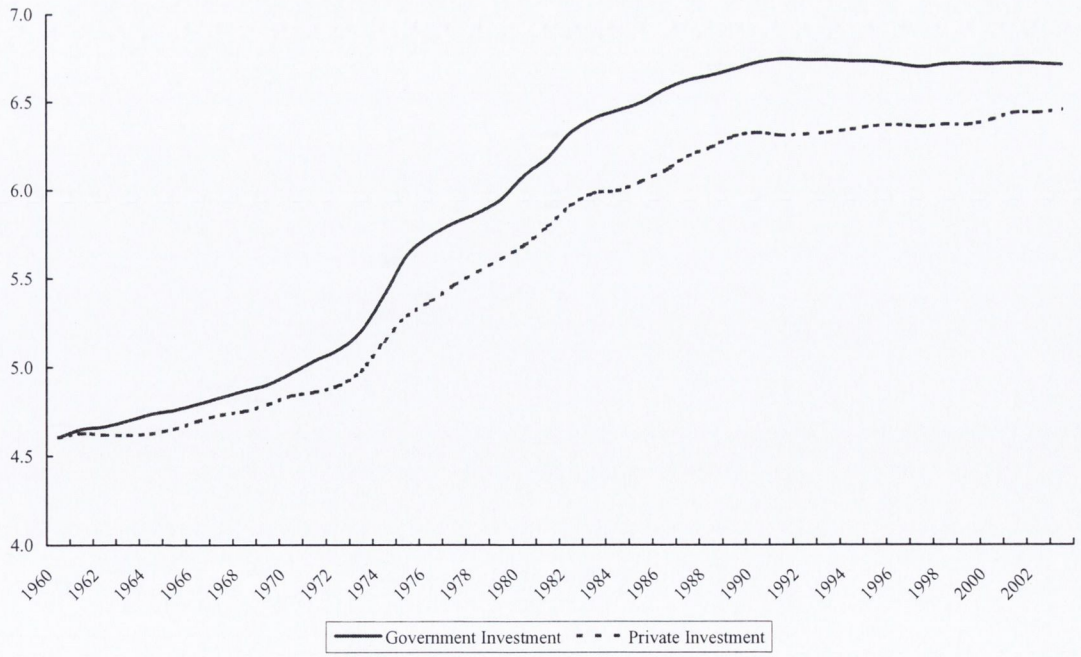


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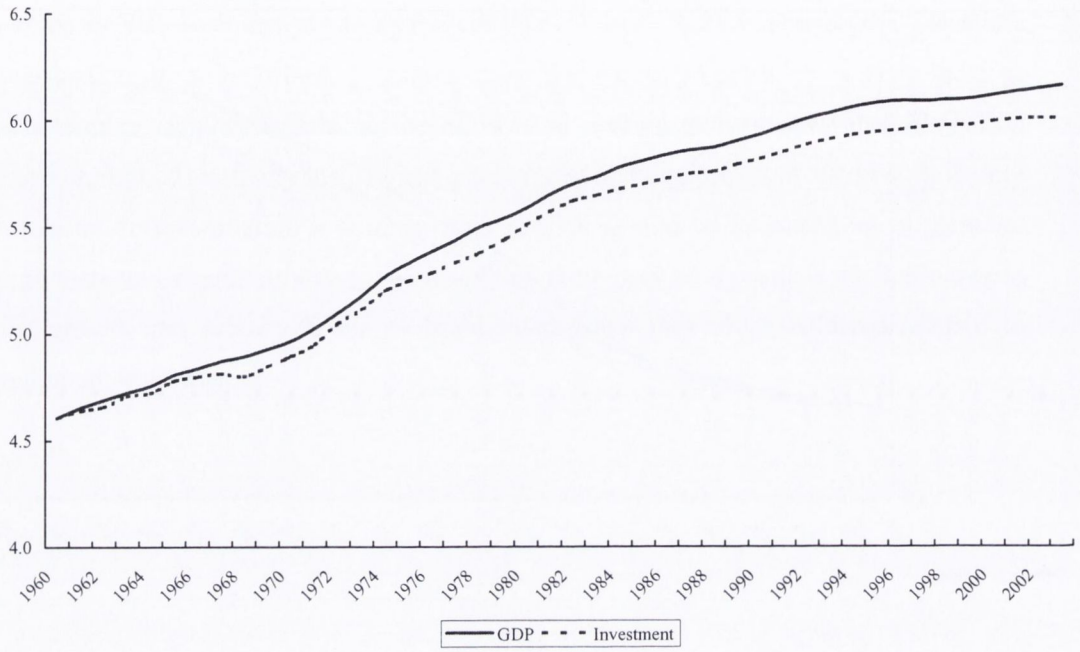


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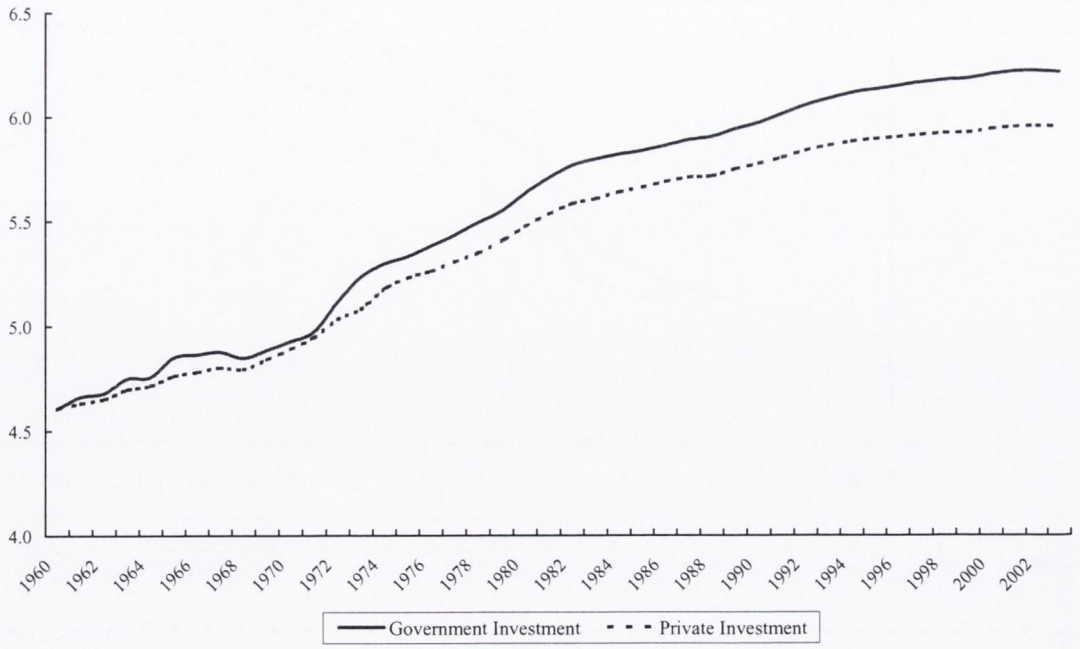


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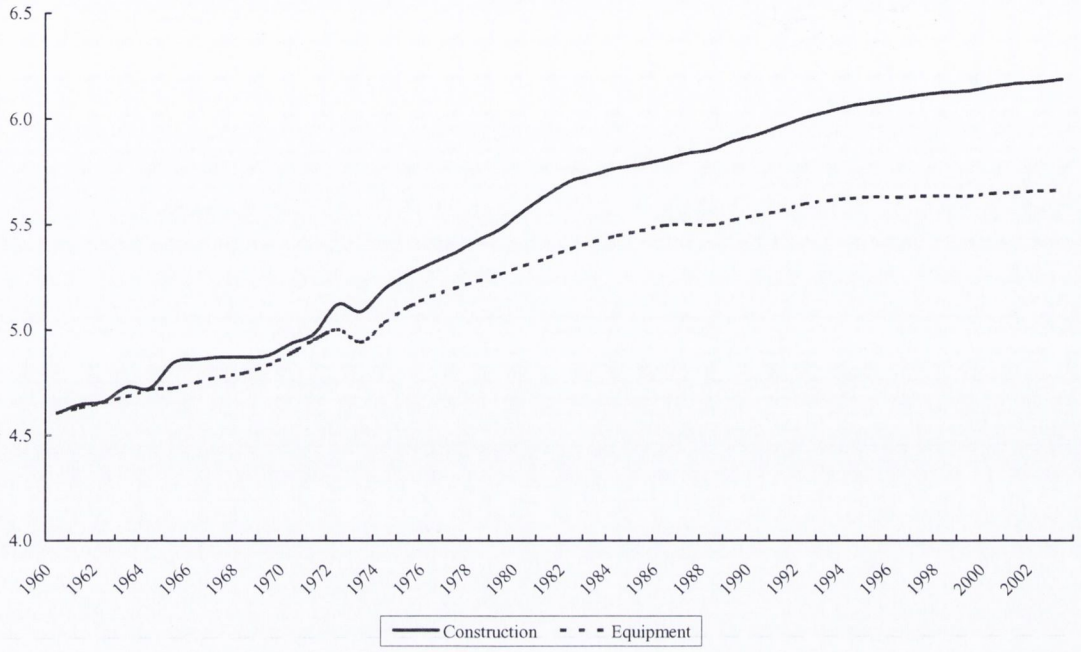


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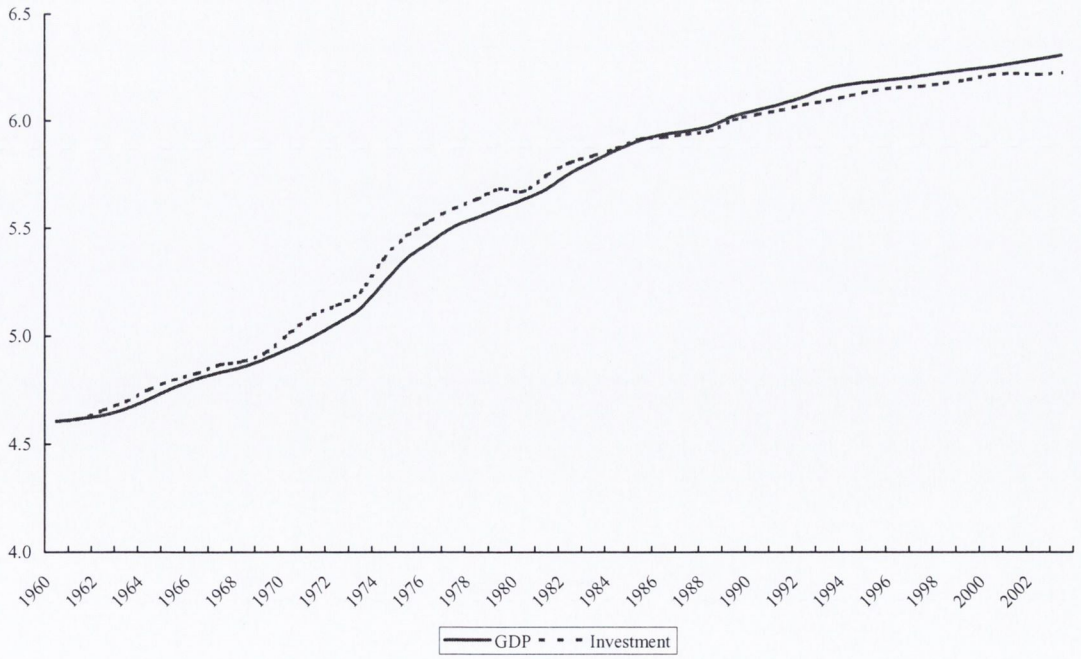


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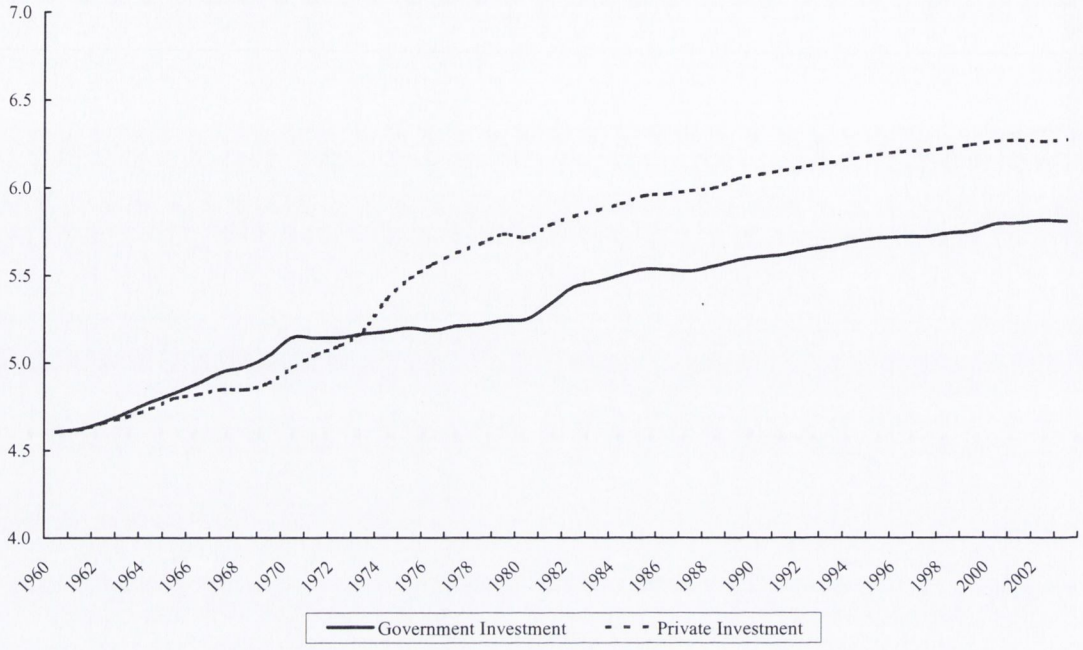


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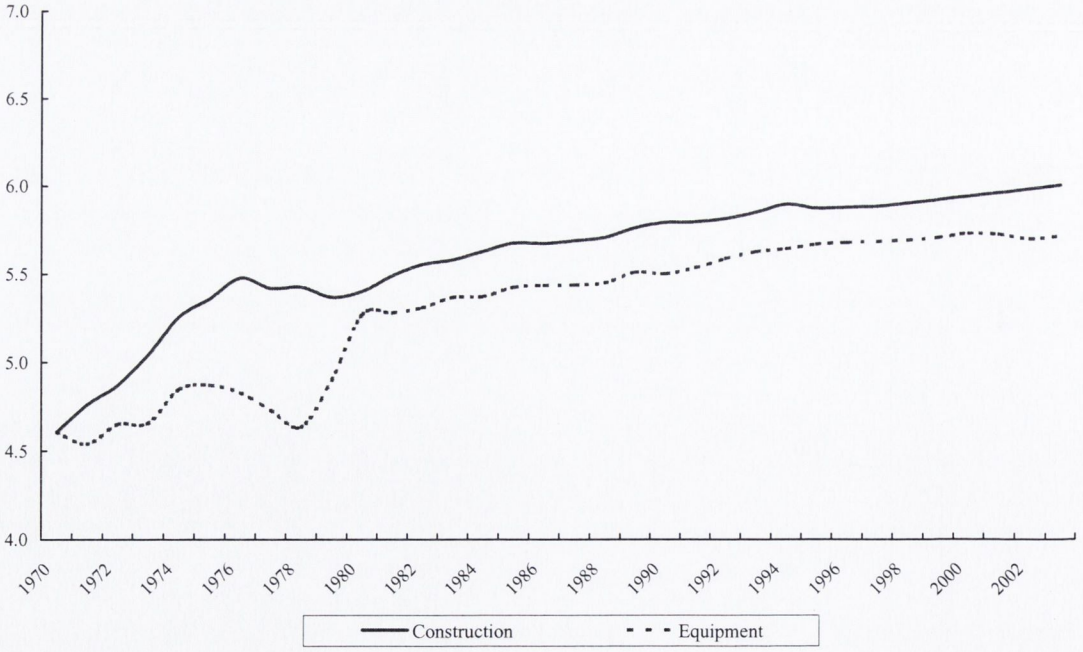


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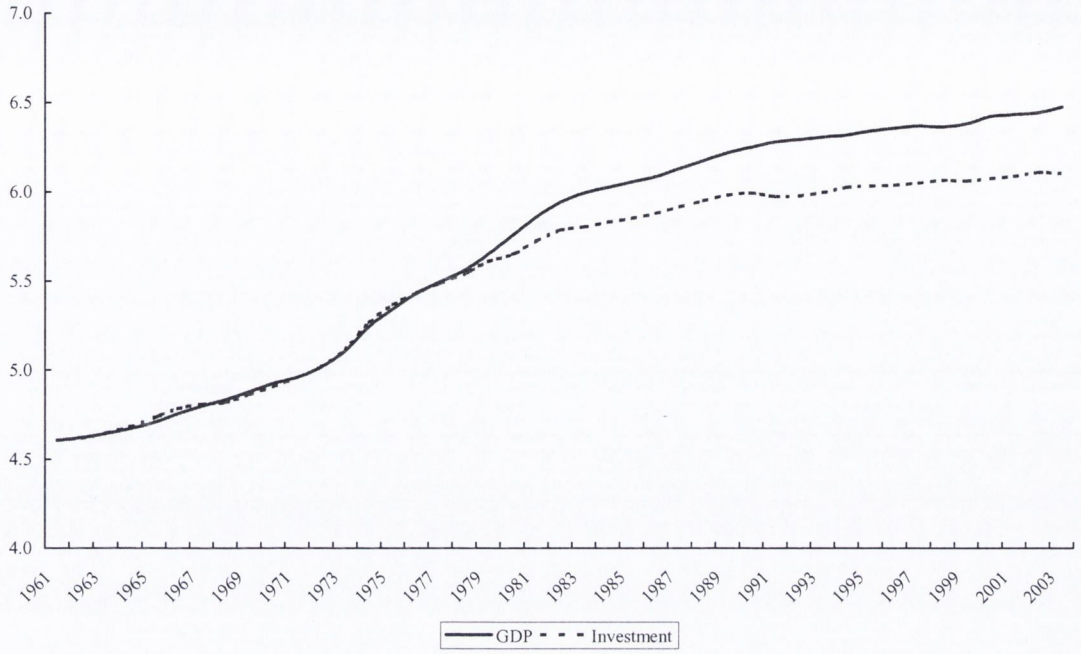


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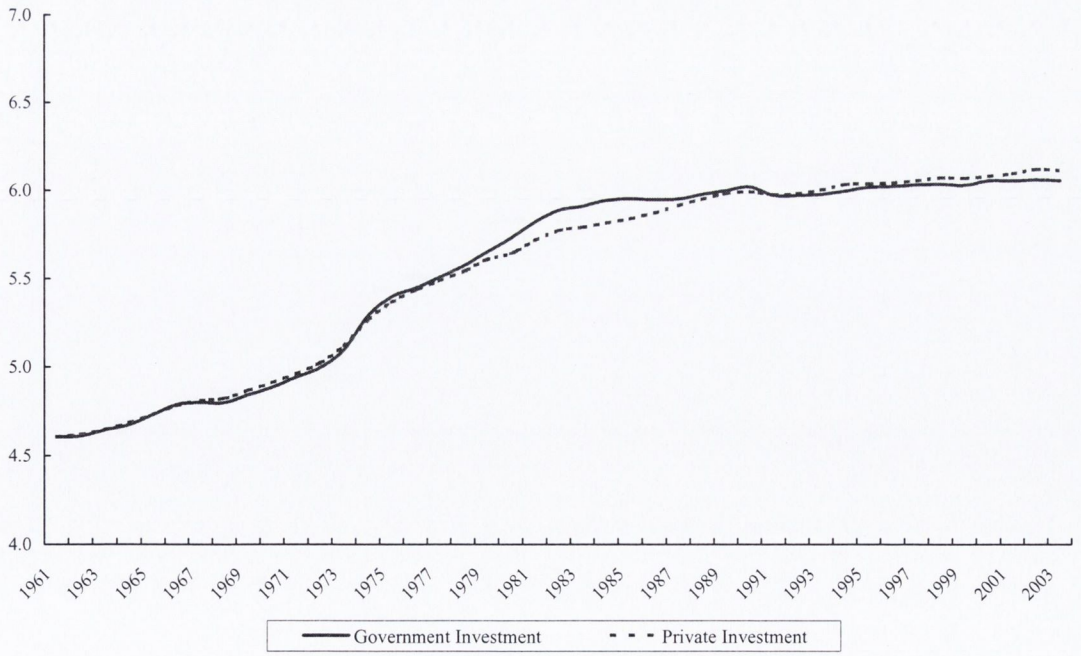


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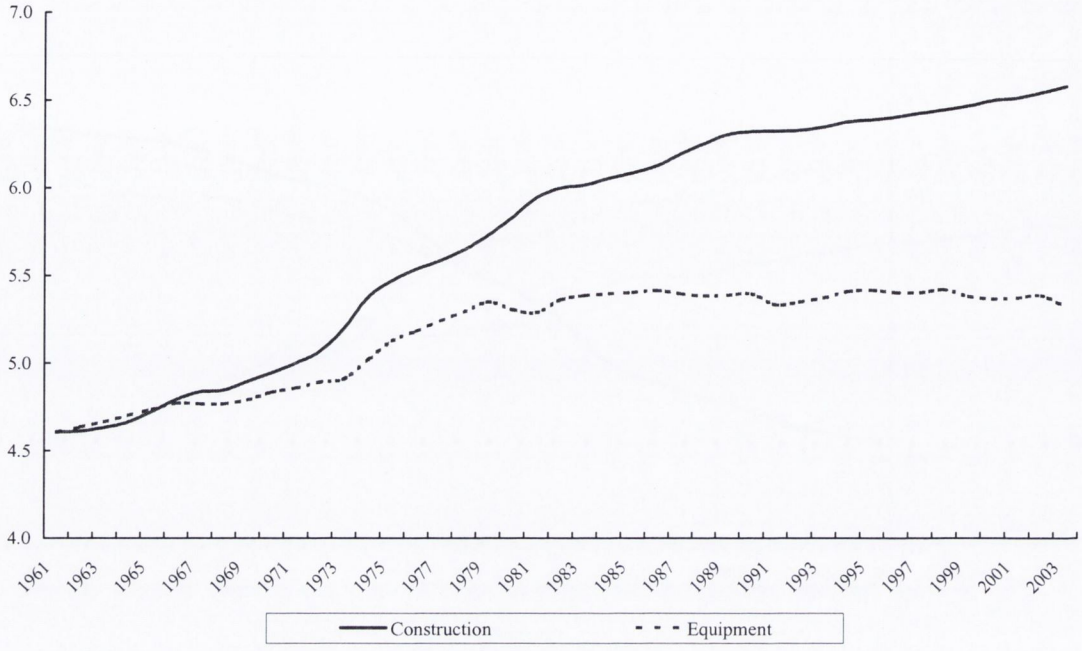


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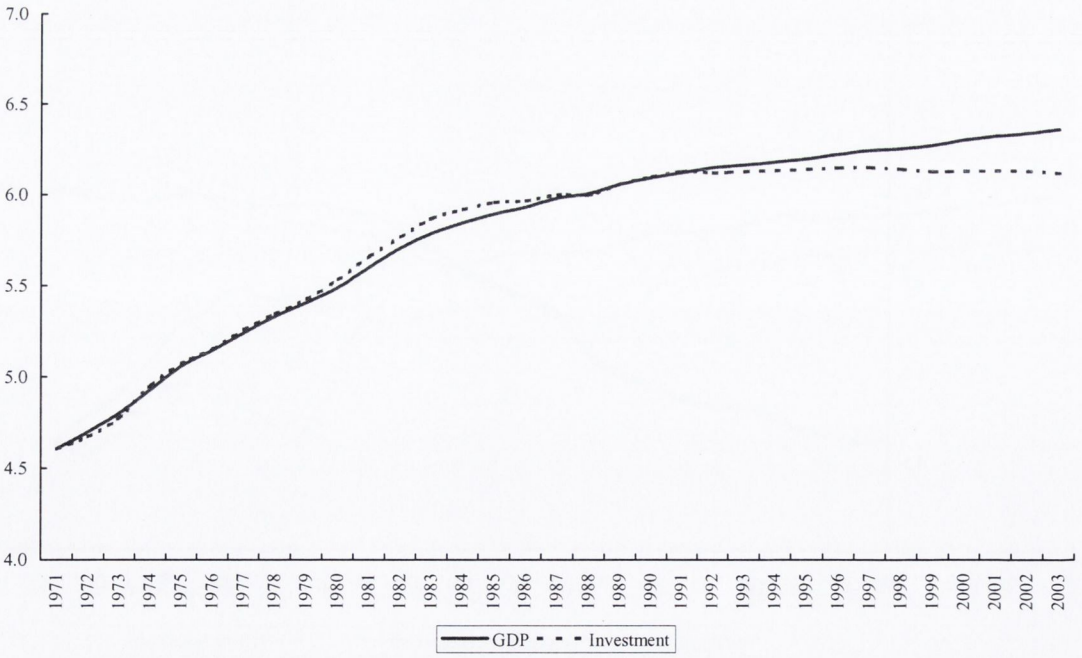


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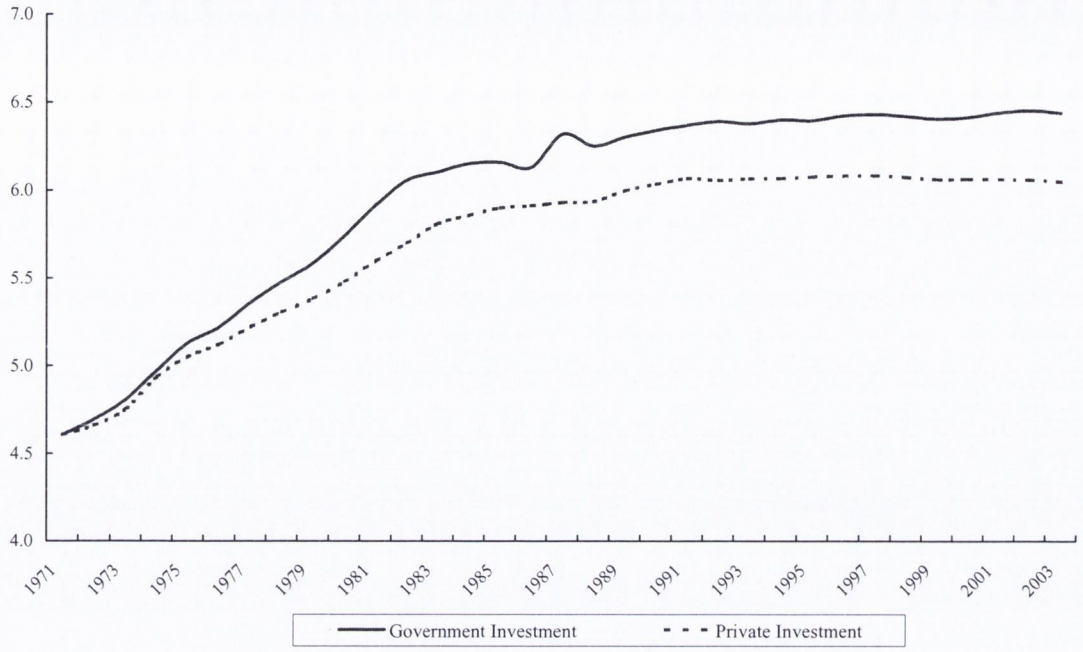


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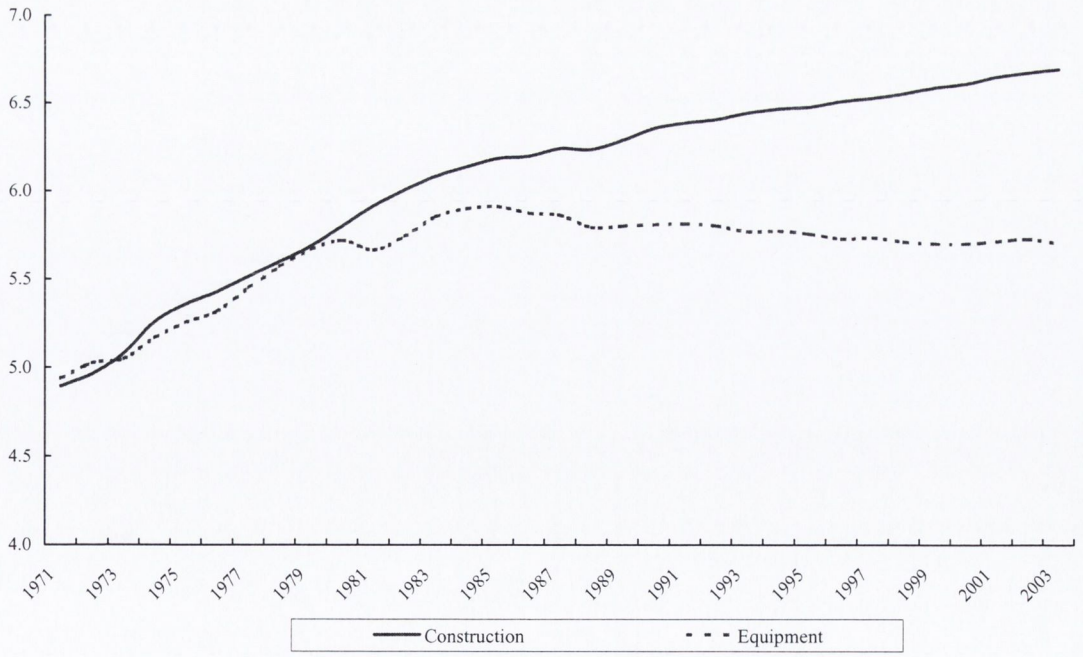


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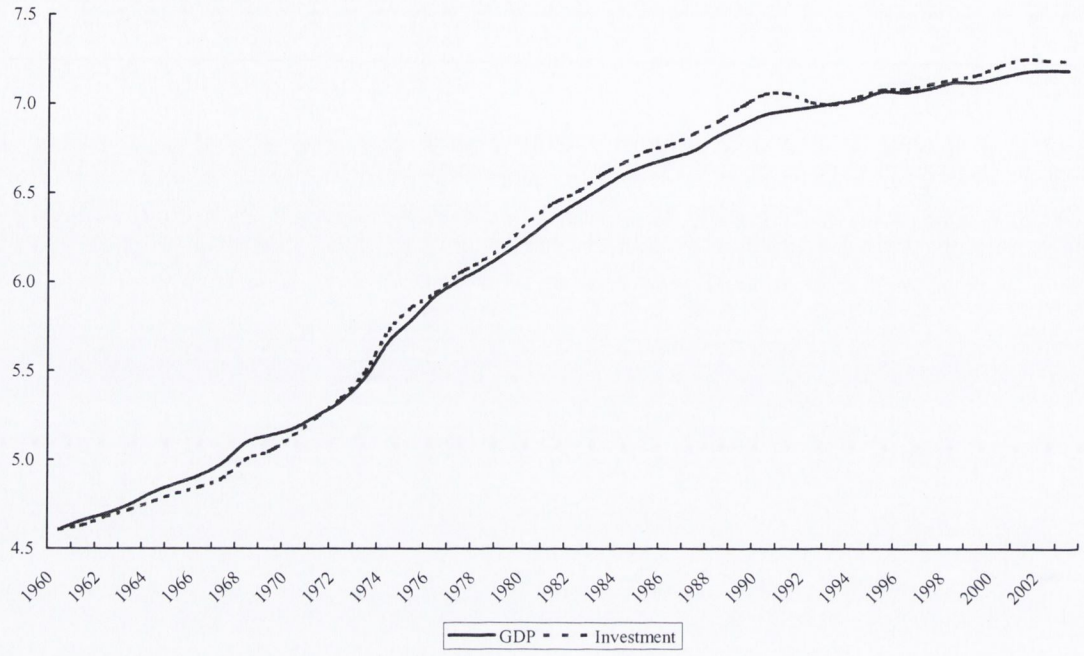


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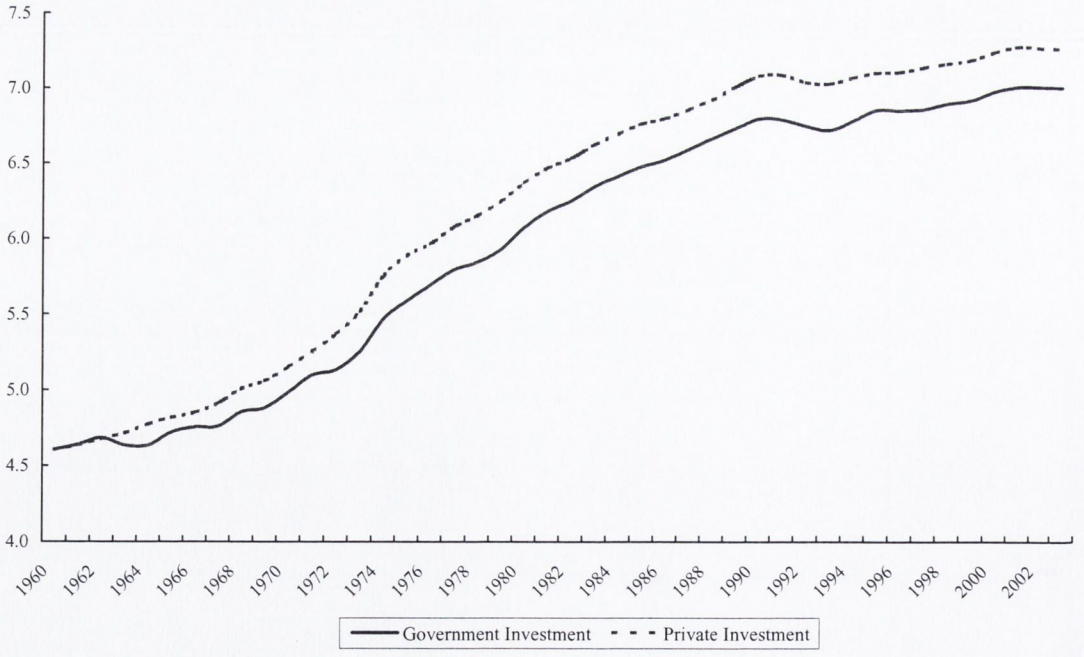


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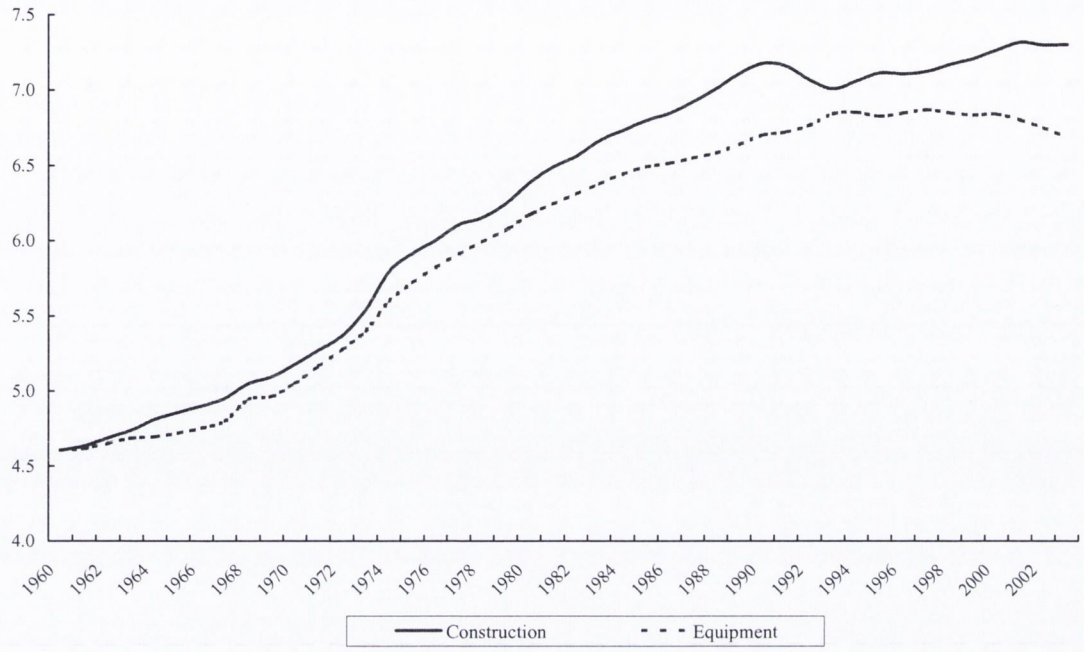


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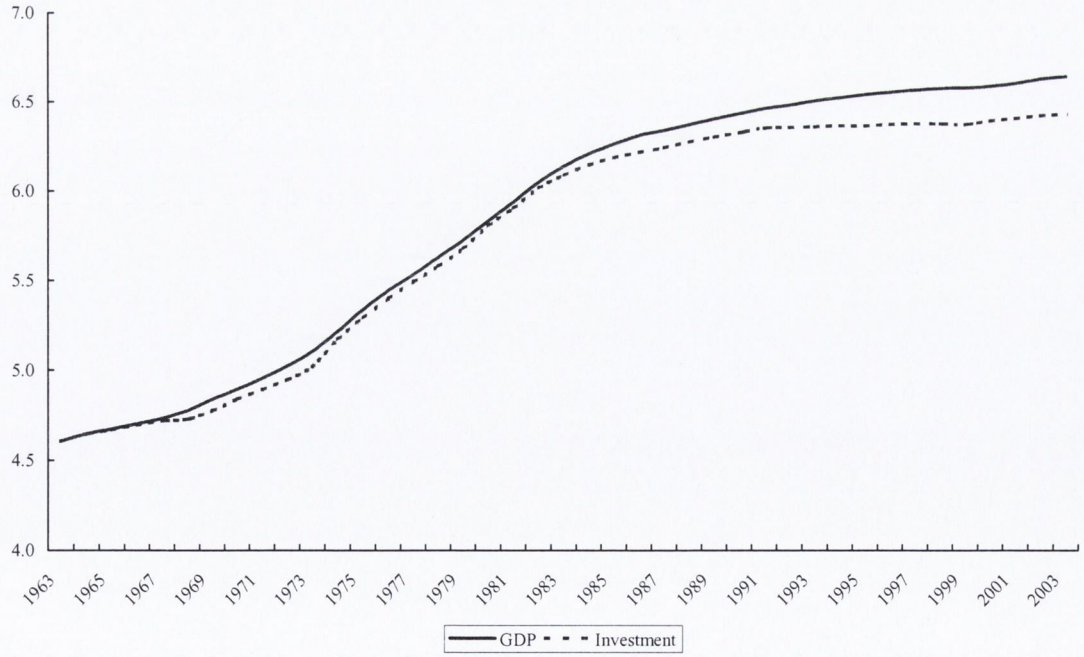


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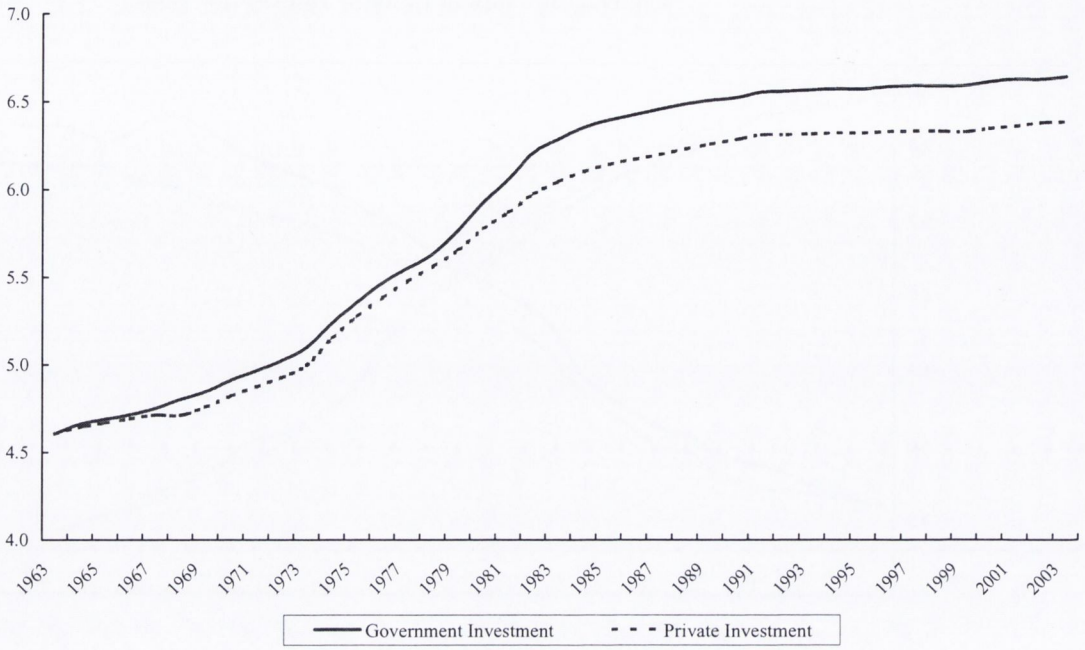


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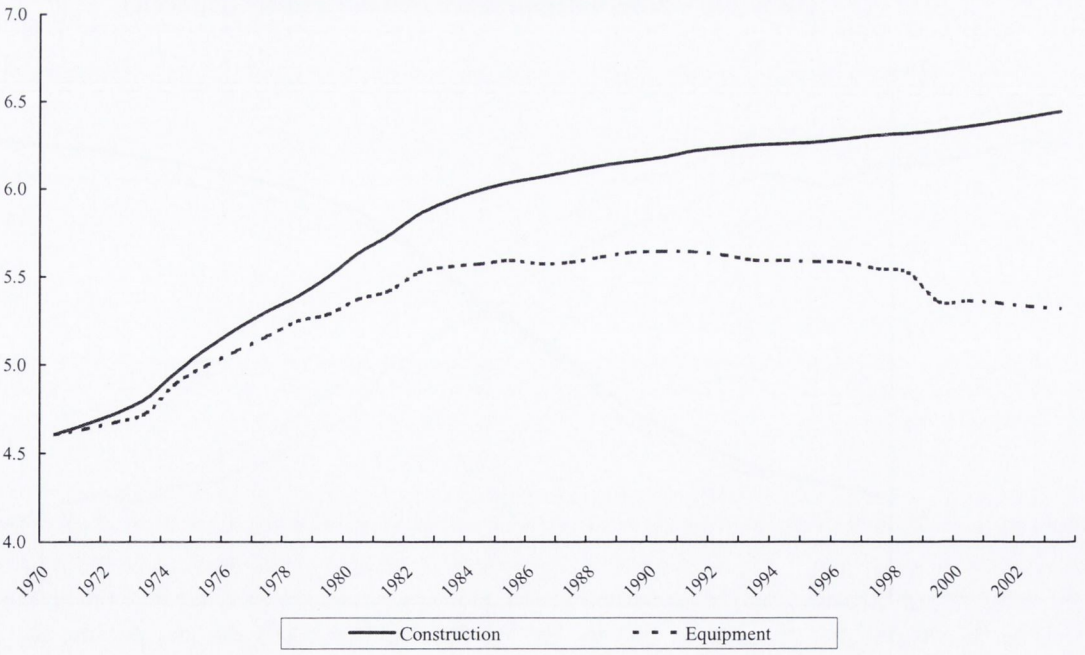


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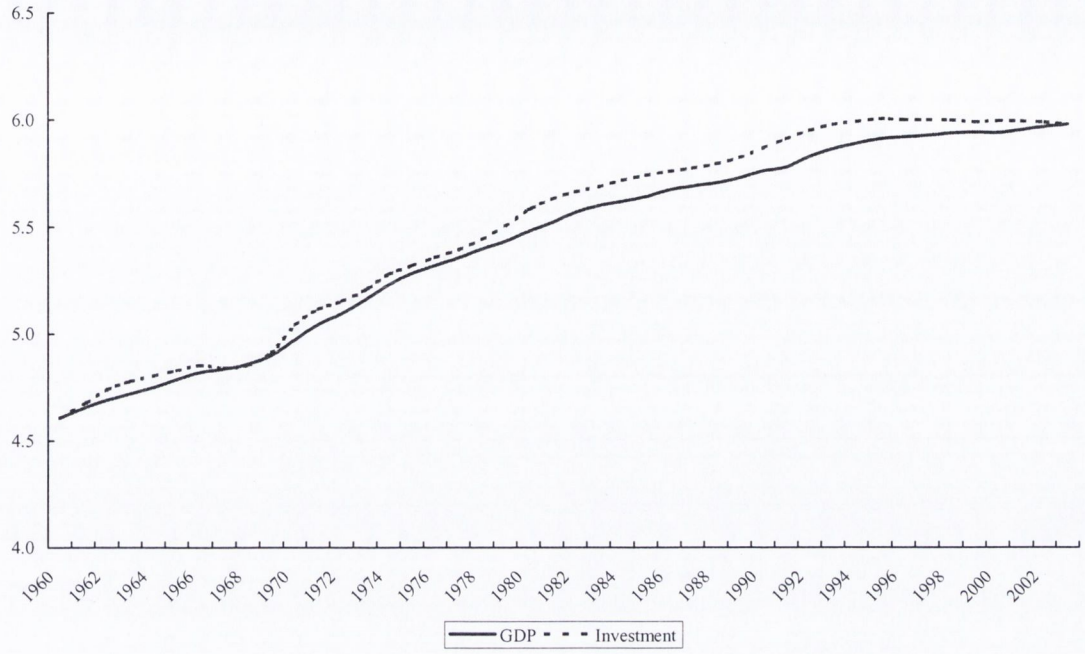


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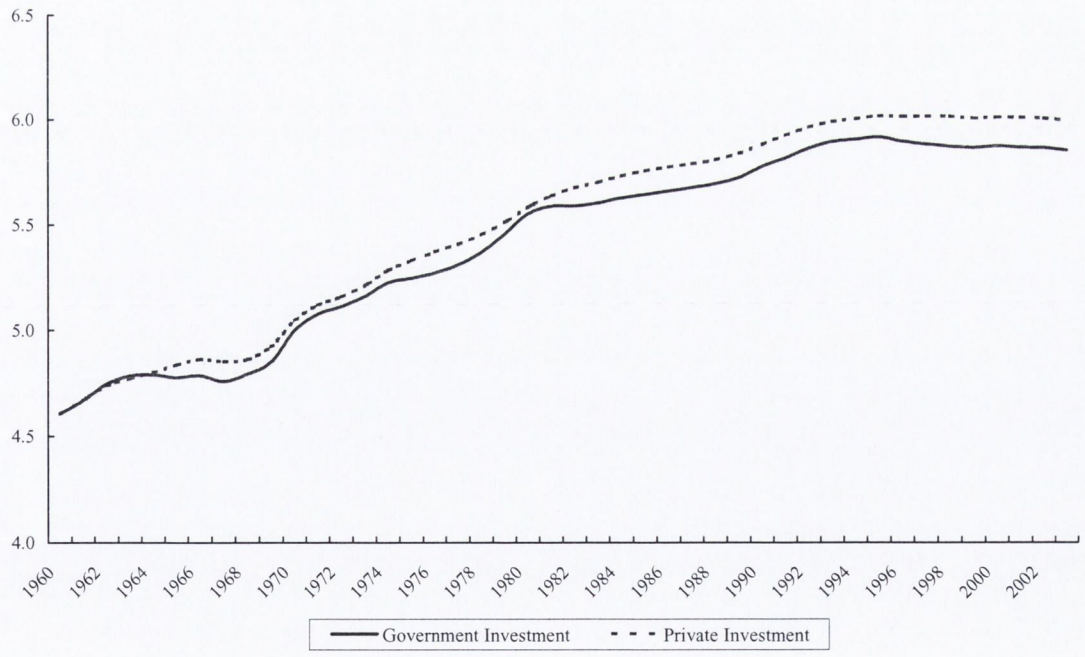


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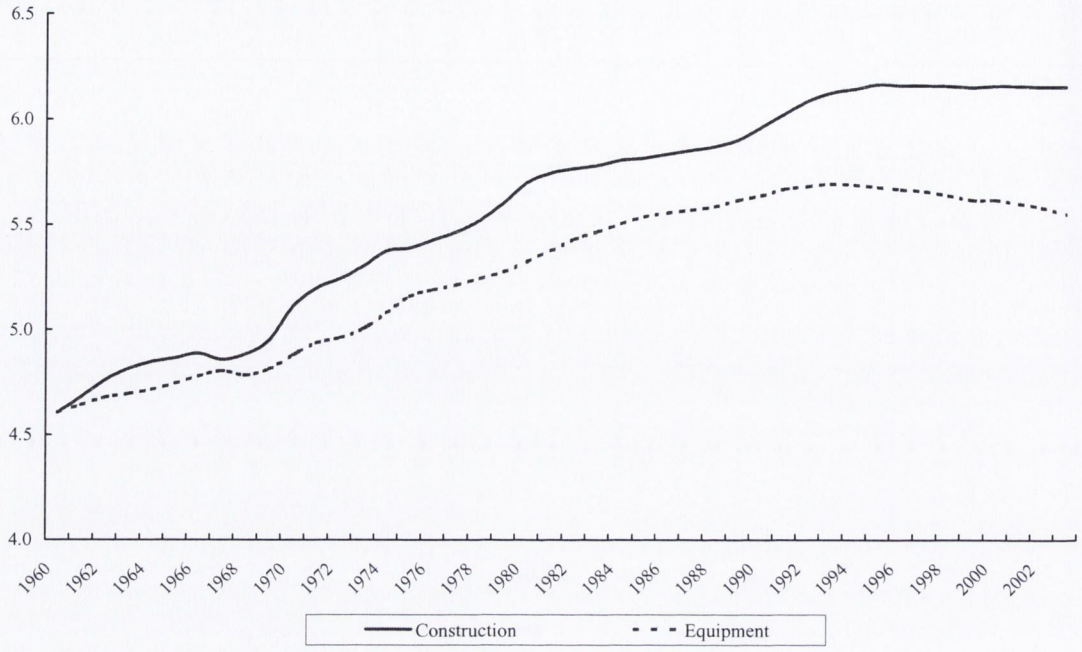


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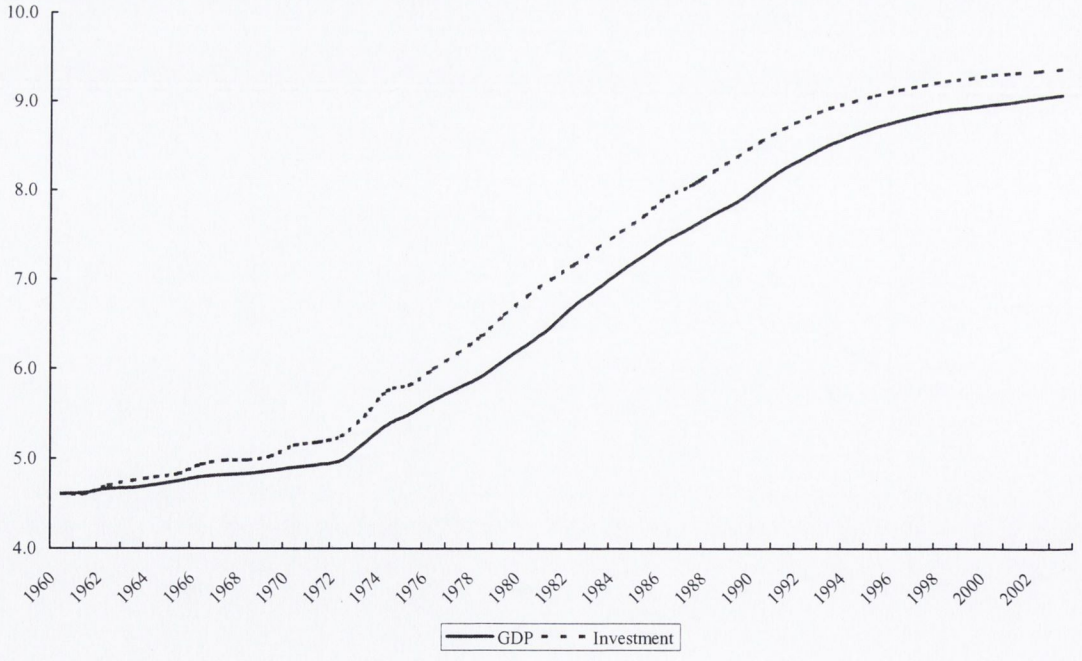


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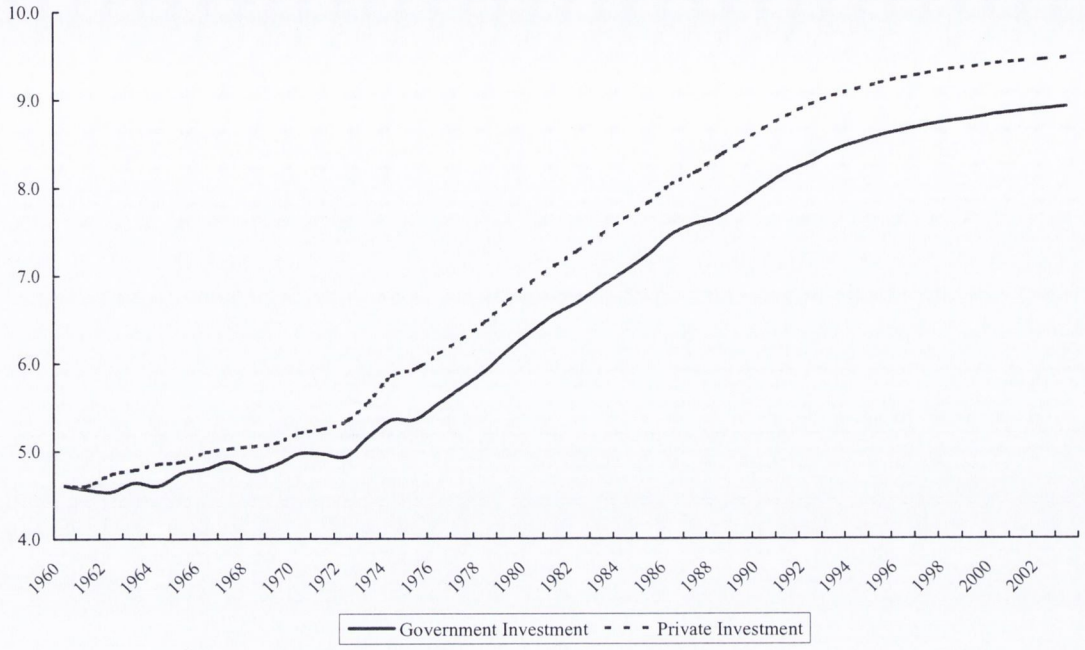


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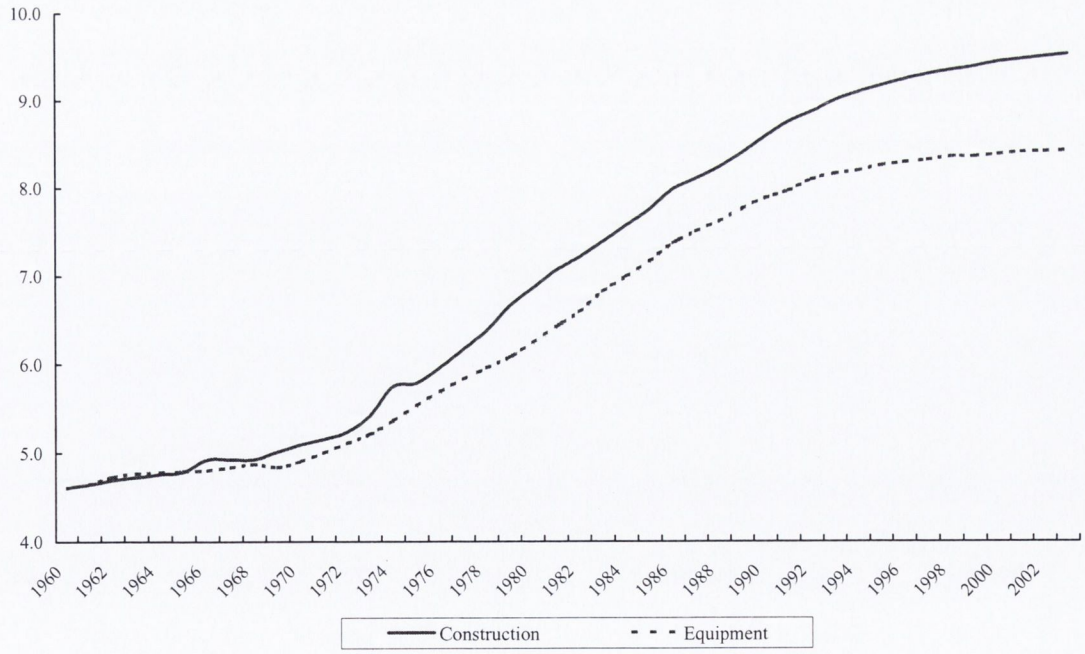


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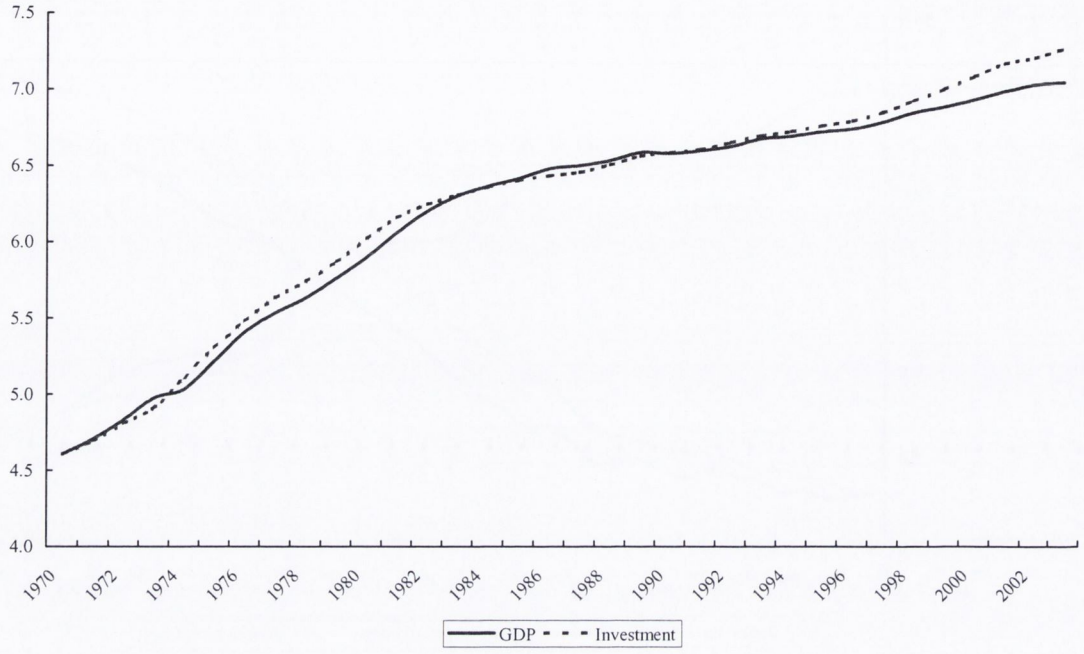


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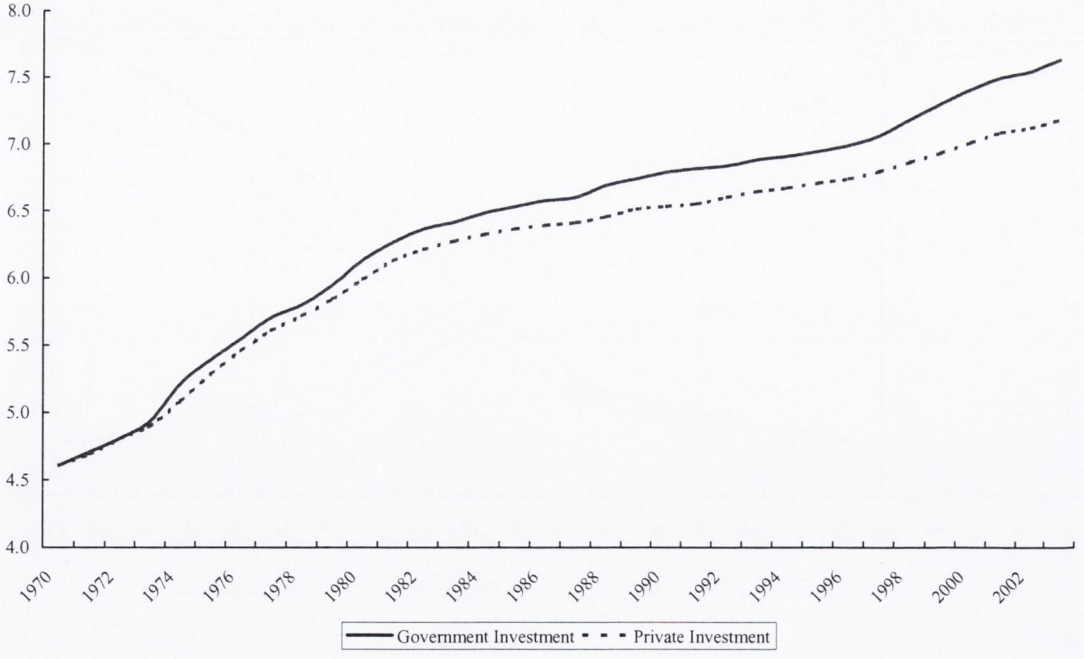


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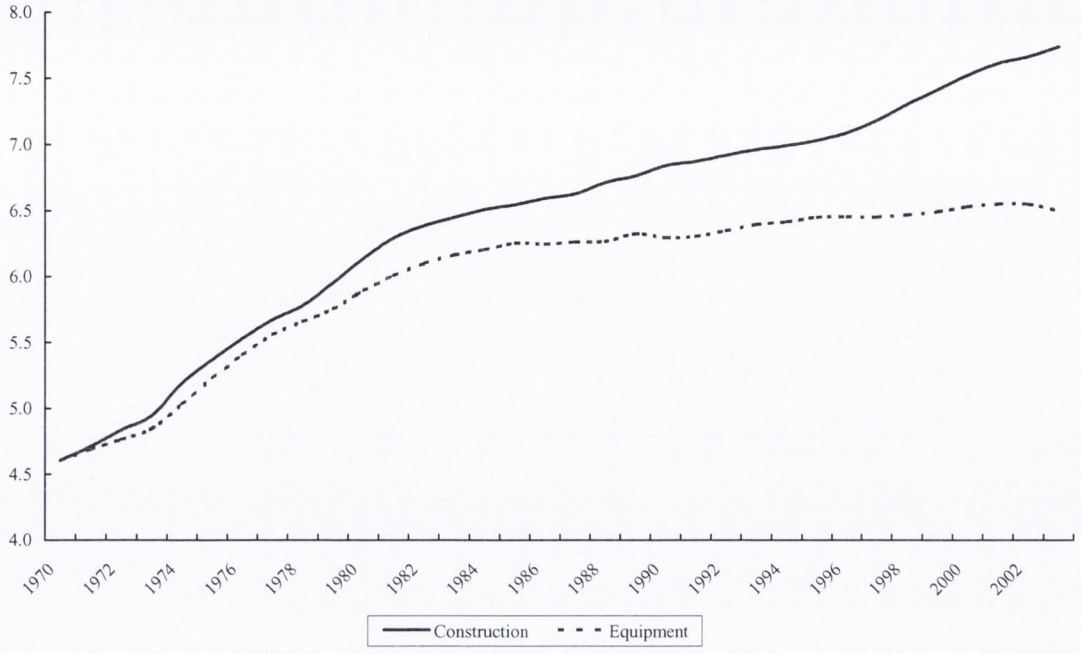


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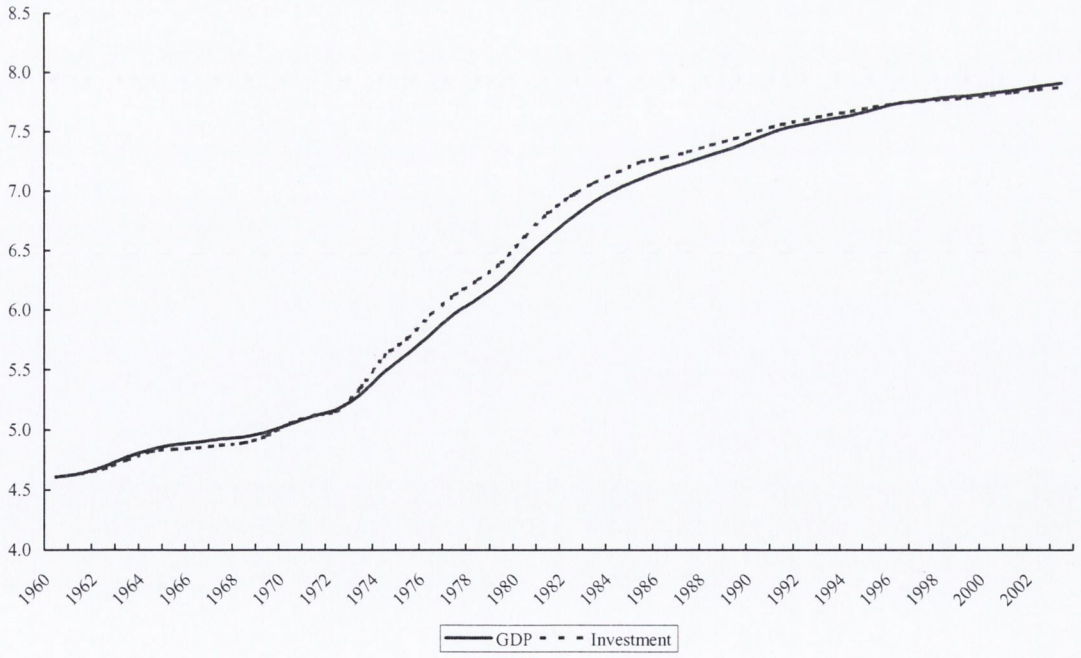


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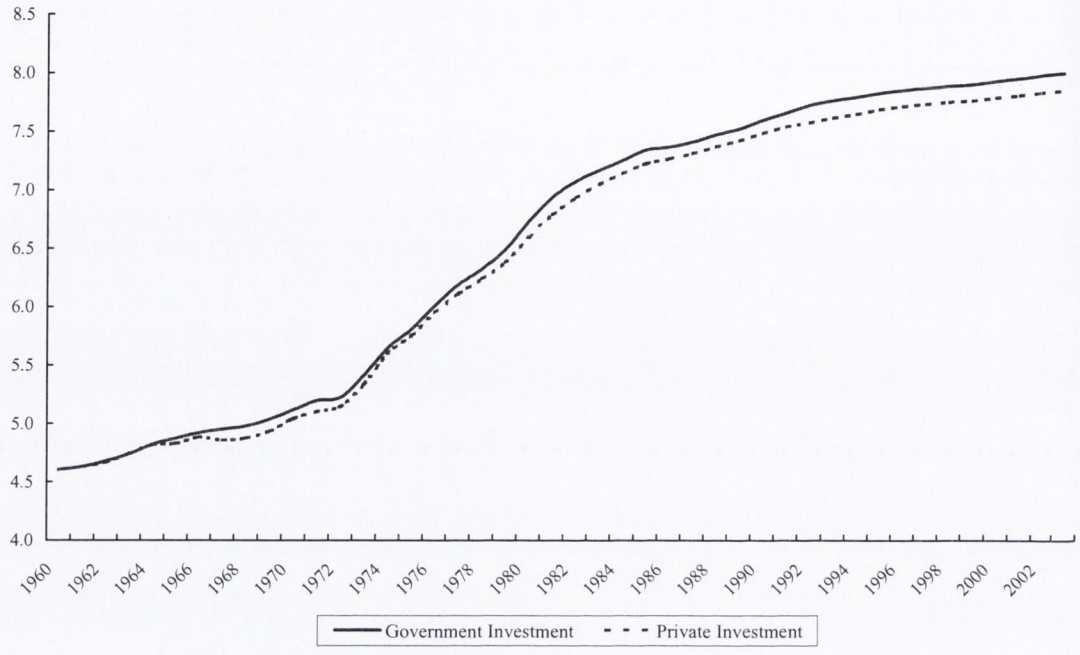


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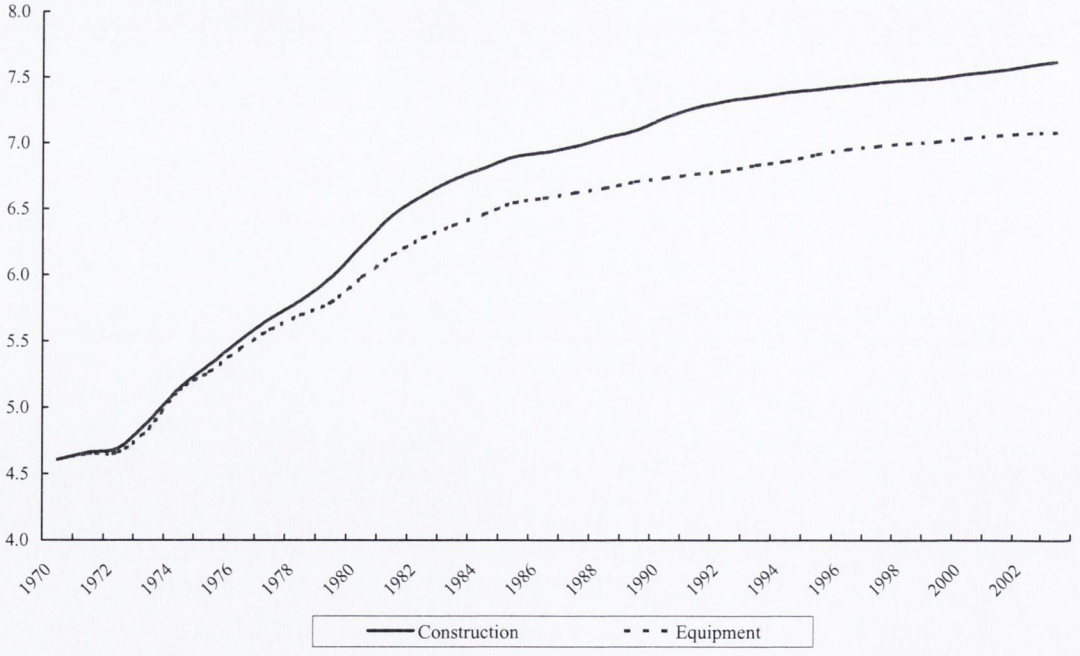


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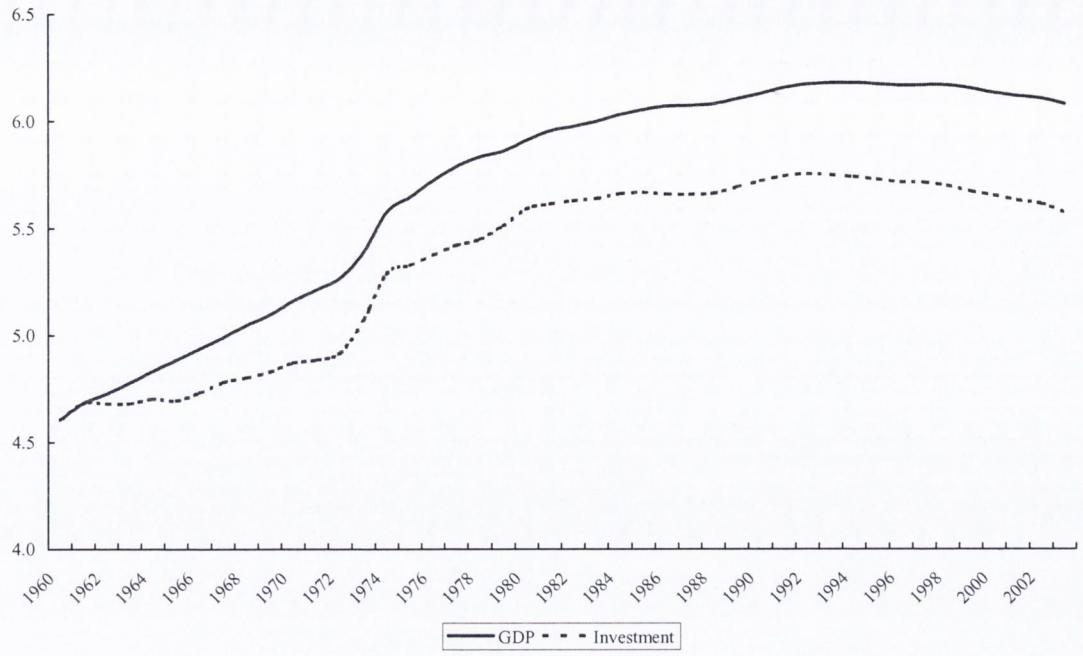


Chart 4.1lb Japan Deflator Indices (log scale)

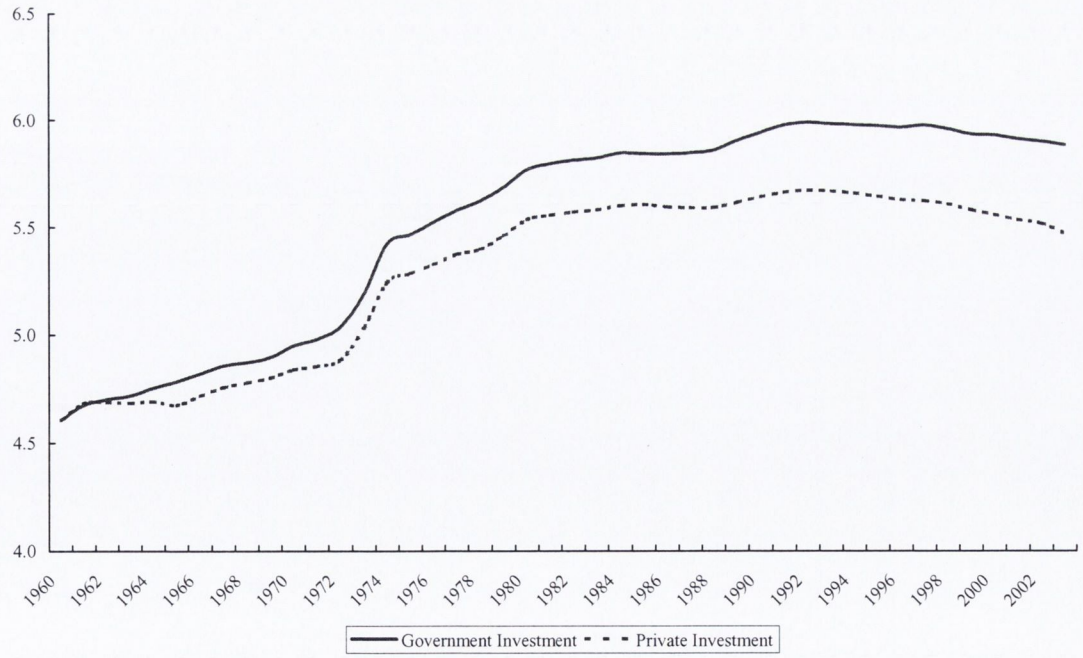


Chart 4.1lc Japan Deflator Indices (log scale)

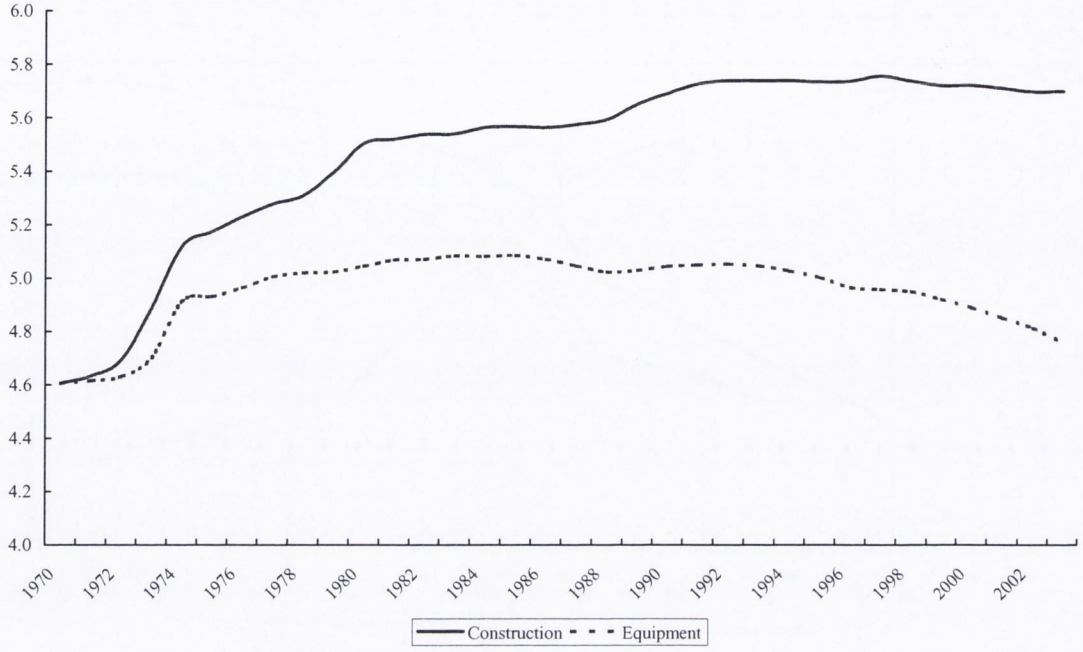


Chart 4.1ma Netherlands Deflator Indices (log scale)

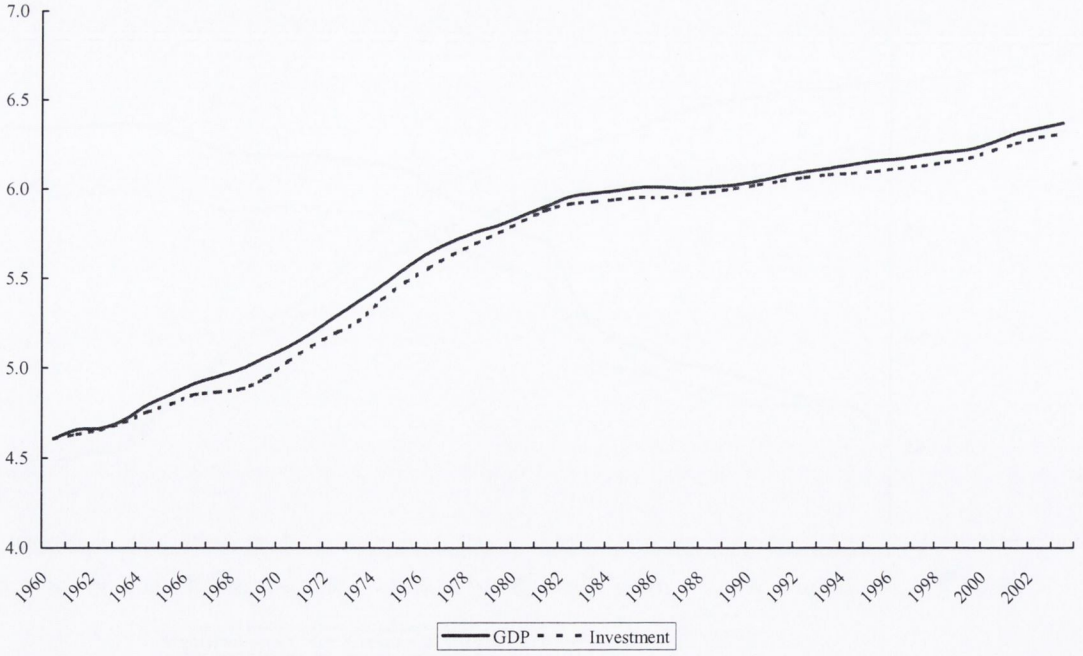


Chart 4.1mb Netherlands Deflator Indices (log scale)

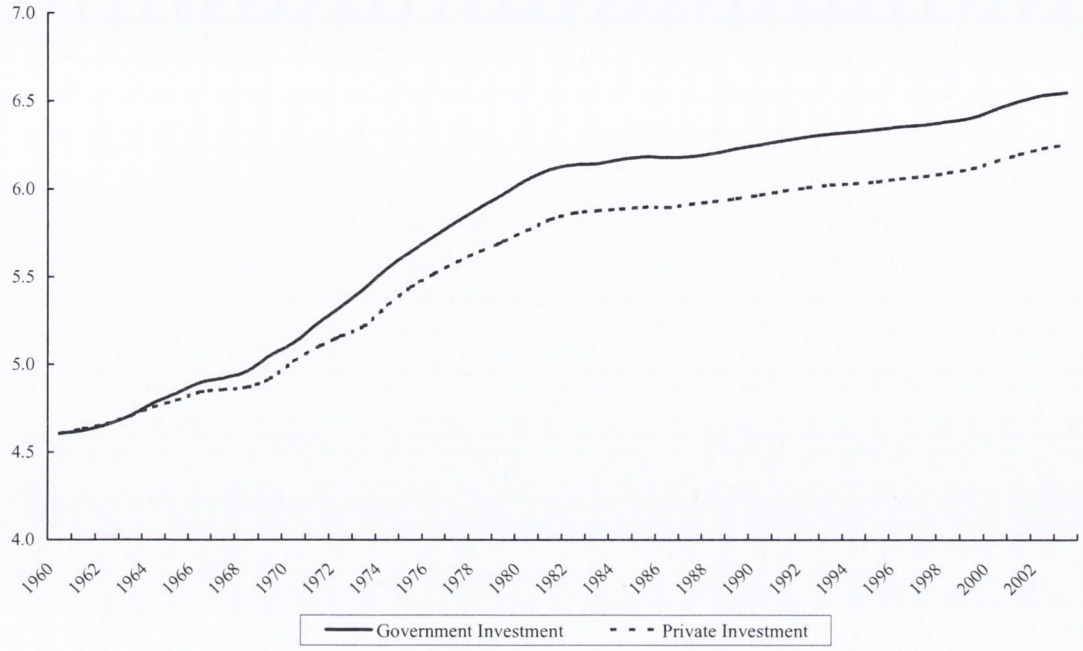


Chart 4.1mc Netherlands Deflator Indices (log scale)

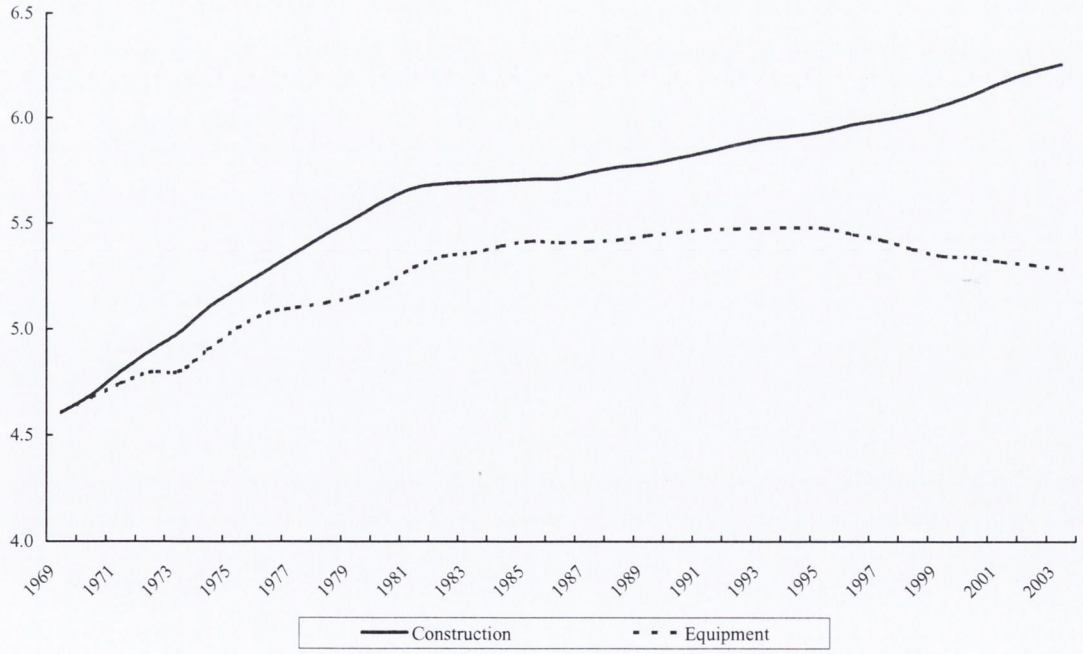


Chart 4.1na New Zealand Deflator Indices (log scale)

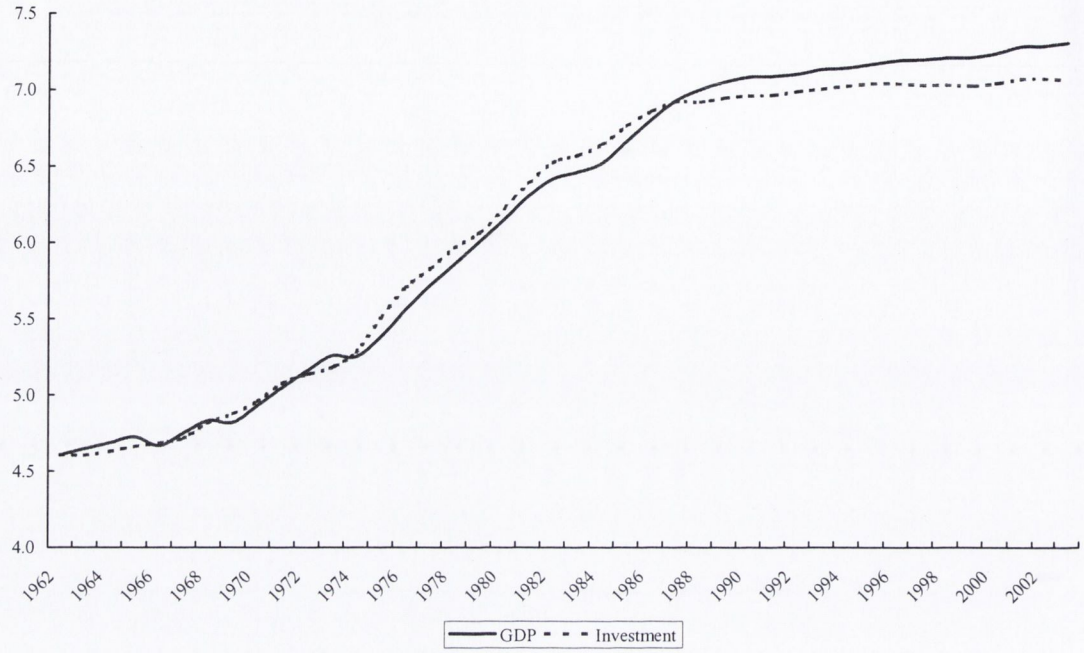


Chart 4.1nb New Zealand Deflator Indices (log scale)

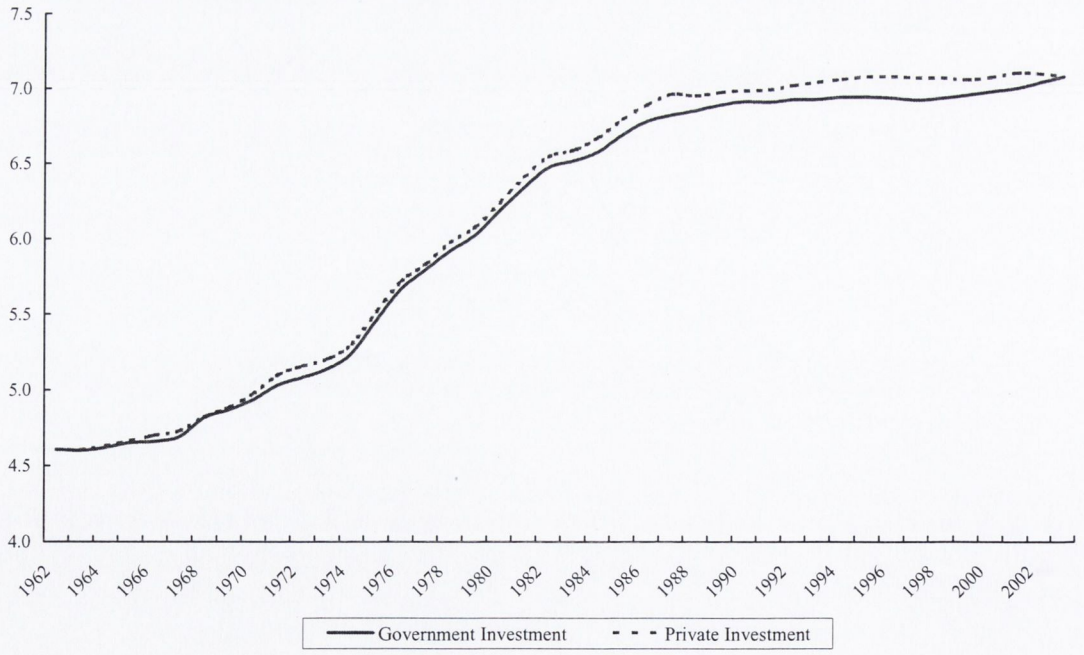


Chart 4.1oa Norway Deflator Indices (log scale)

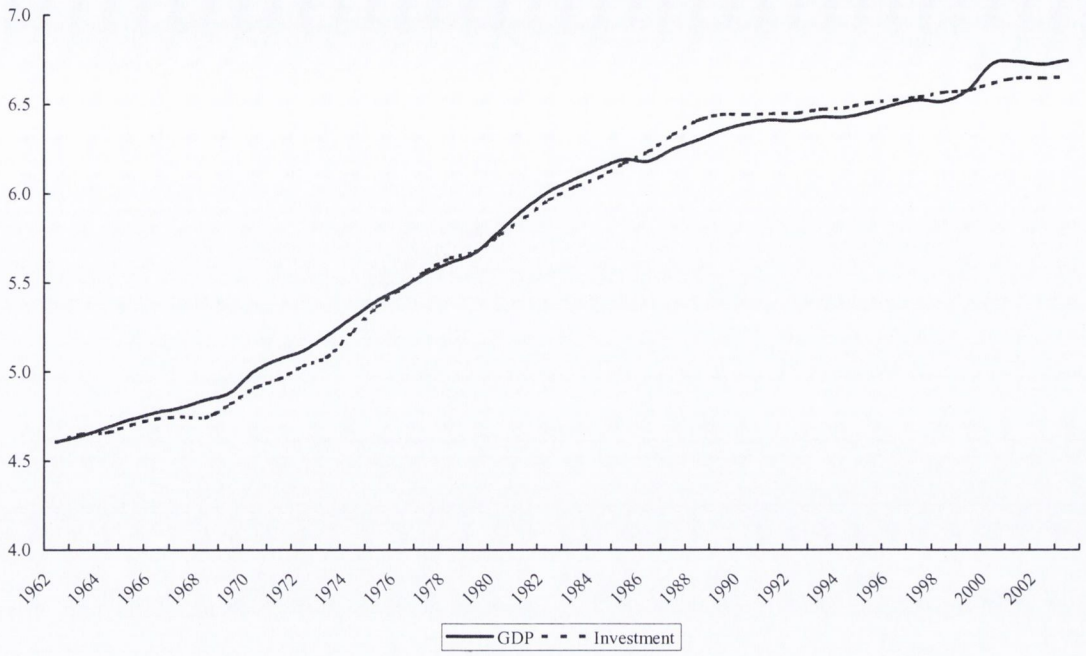


Chart 4.1ob Norway Deflator Indices (log scale)



Chart 4.1oc Norway Deflator Indices (log scale)

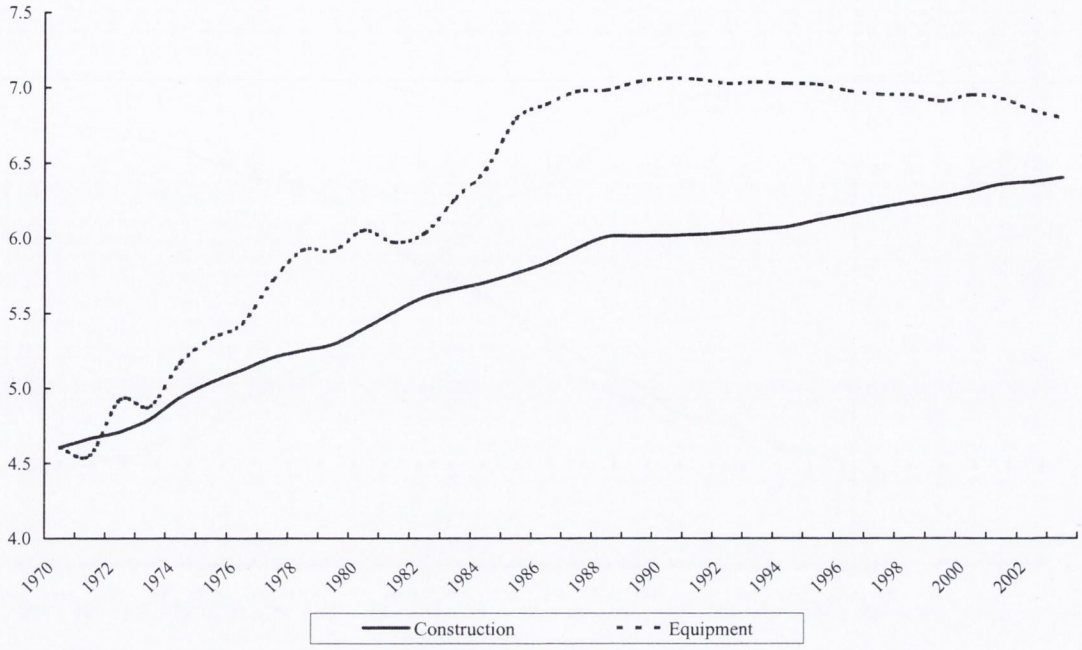


Chart 4.1pa Portugal Deflator Indices (log scale)

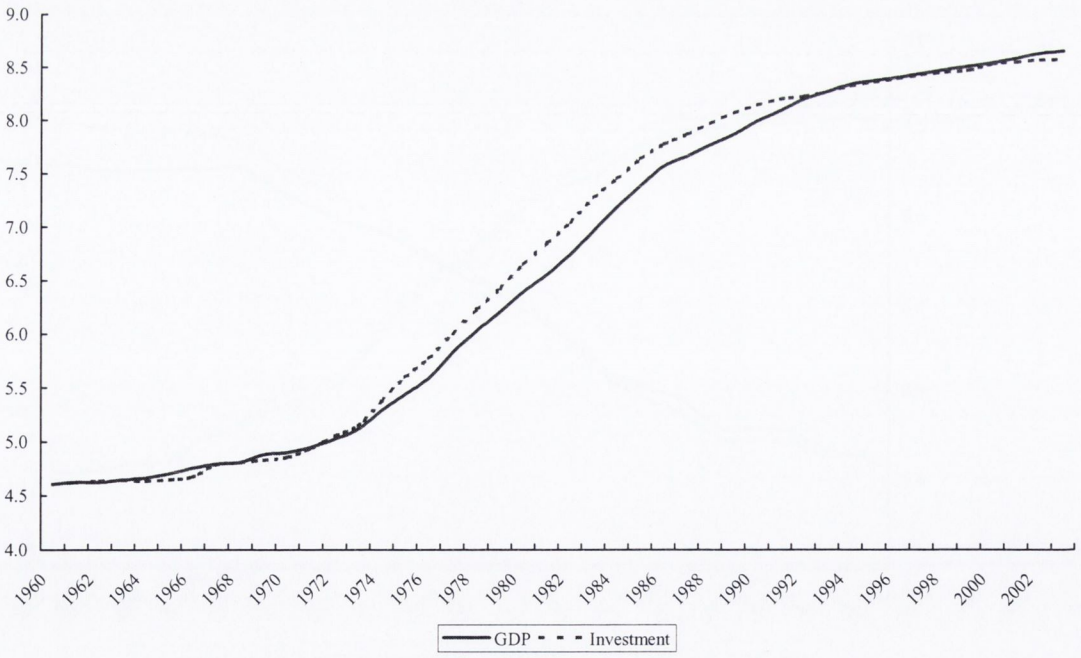


Chart 4.1qa Spain Deflator Indices (log scale)

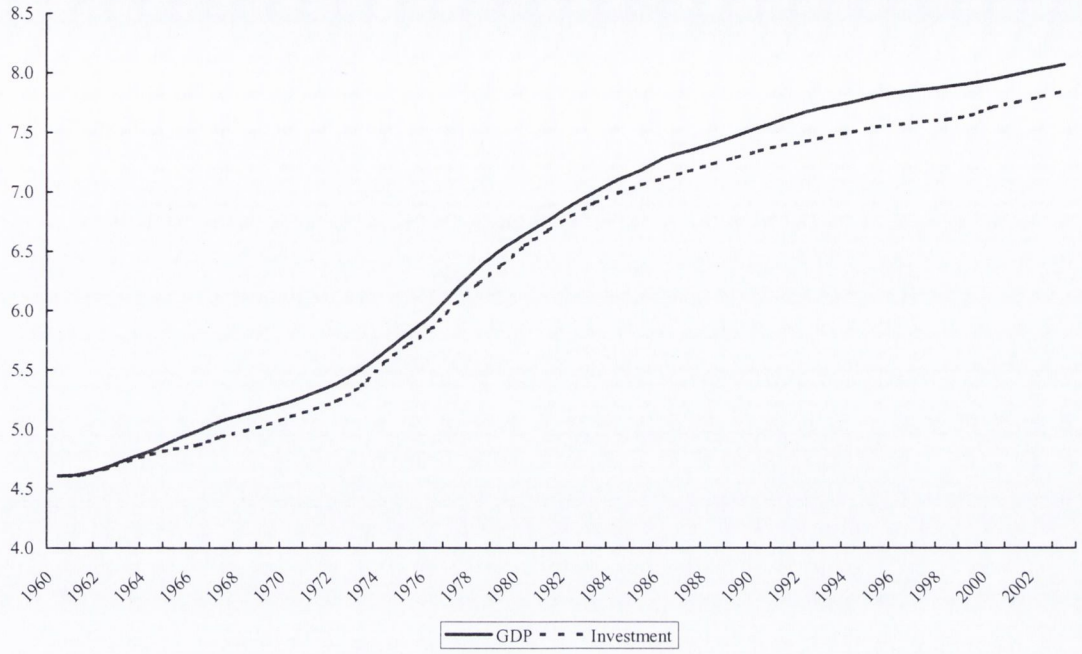


Chart 4.1qb Spain Deflator Indices (log scale)

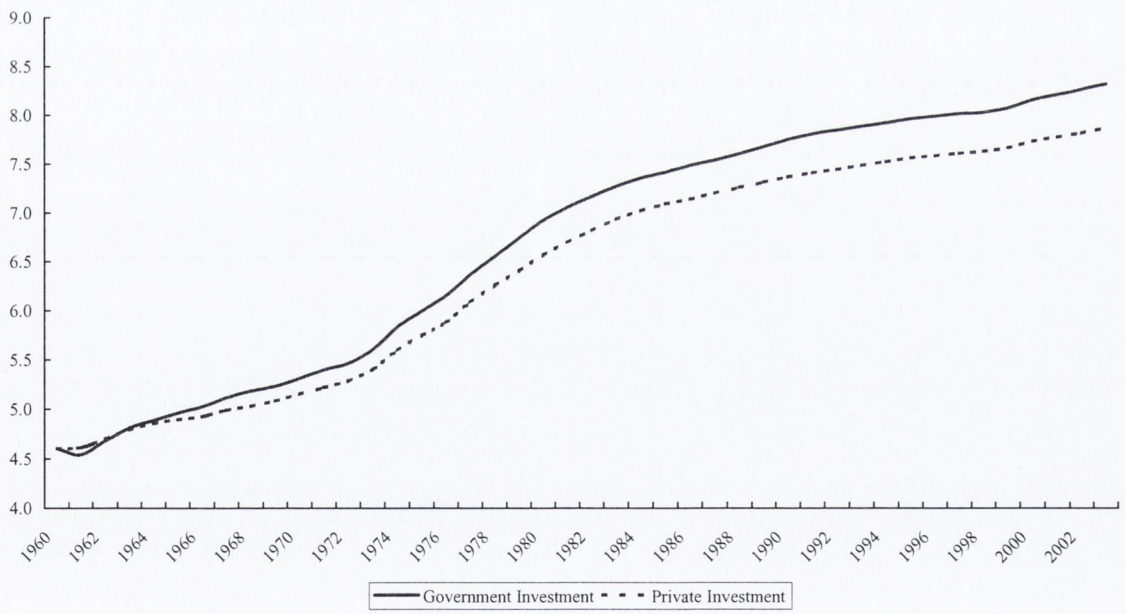


Chart 4.1qc Spain Deflator Indices (log scale)

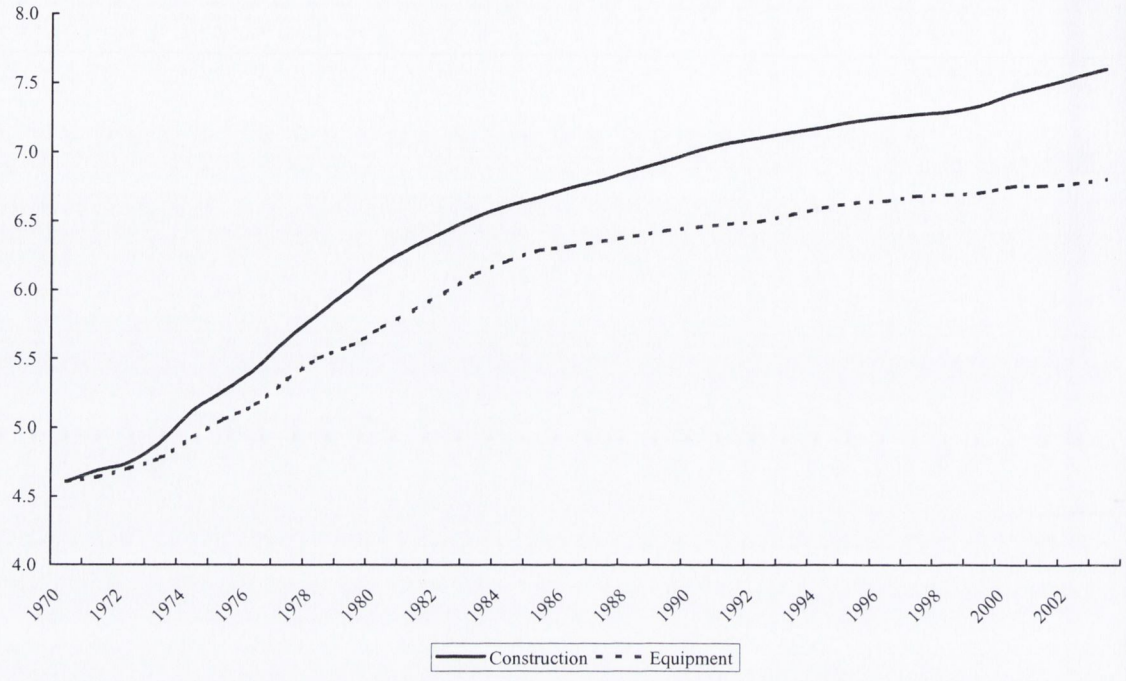


Chart 4.1ra Sweden Deflator Indices (log scale)

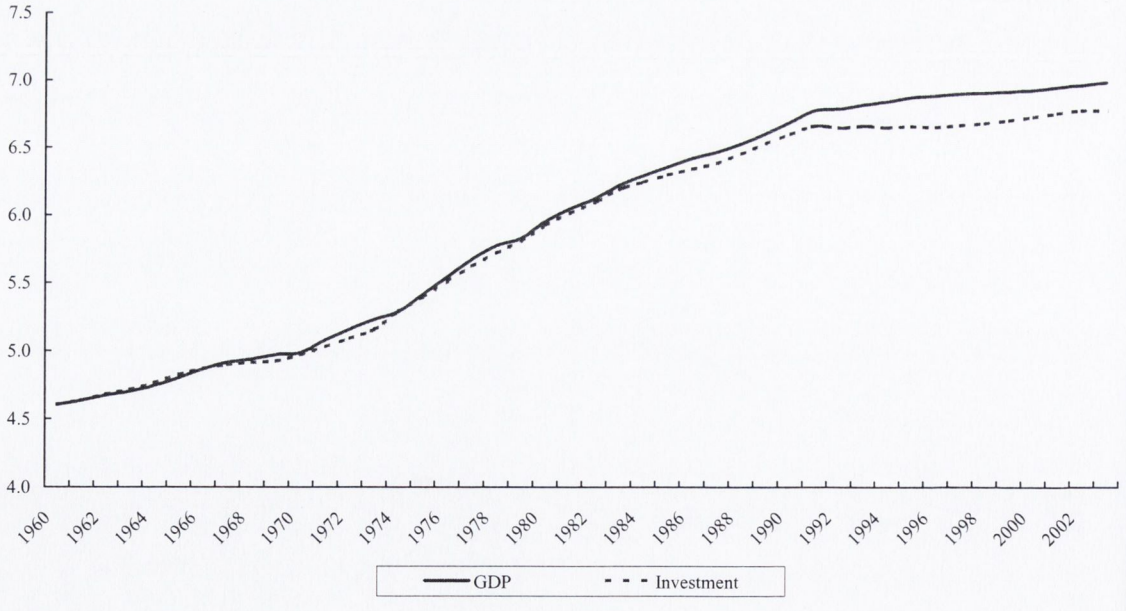


Chart 4.1rb Sweden Deflator Indices (log scale)

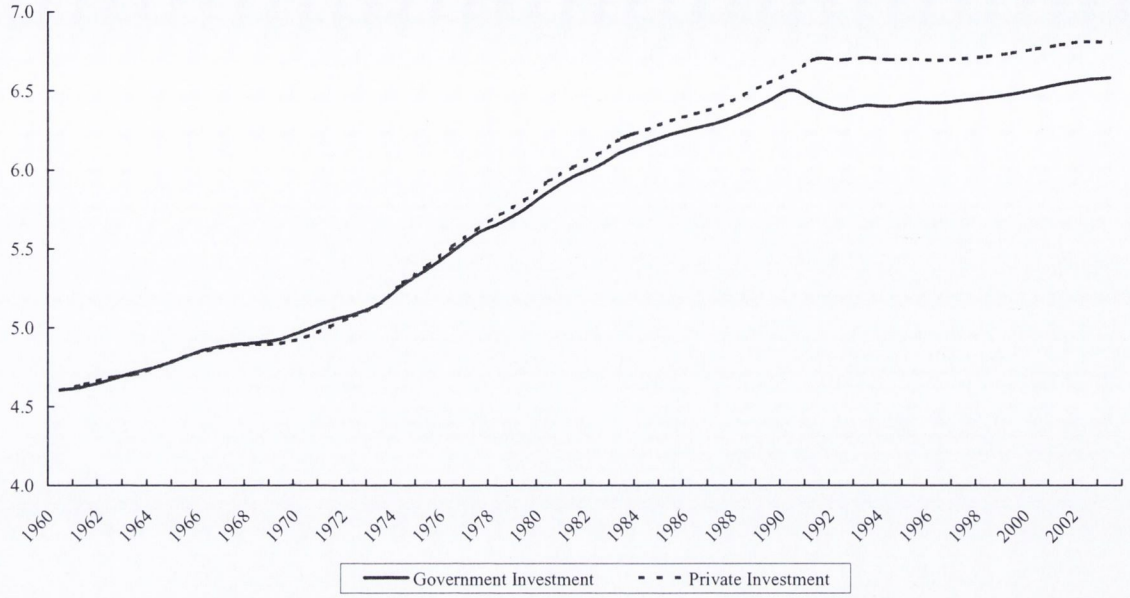


Chart 4.1rc Sweden Deflator Indices (log scale)

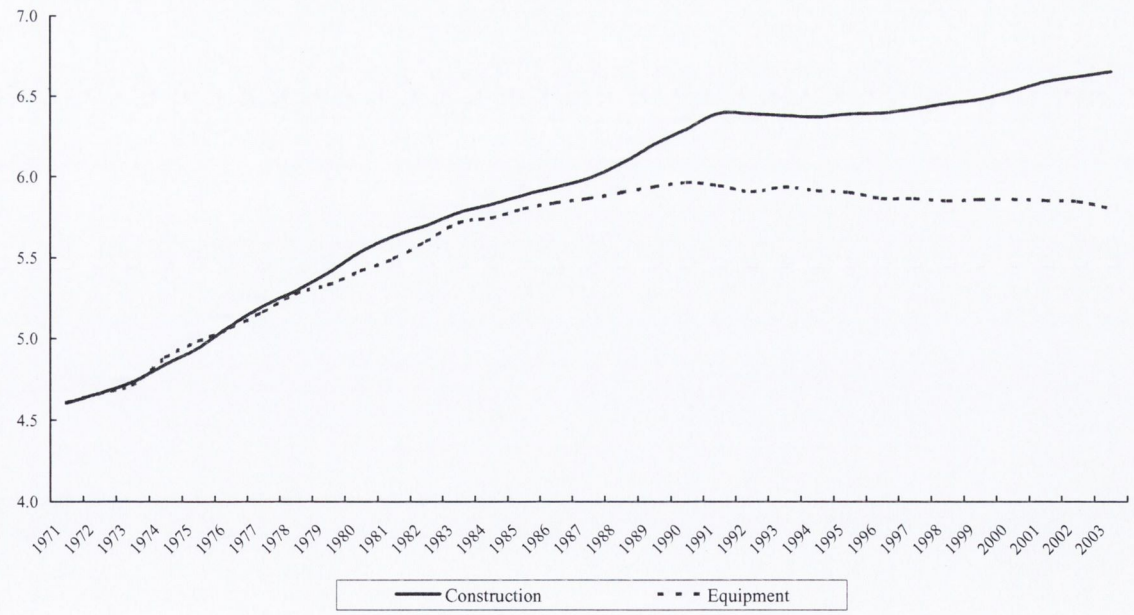


Chart 4.1sa UK Deflator Indices (log scale)

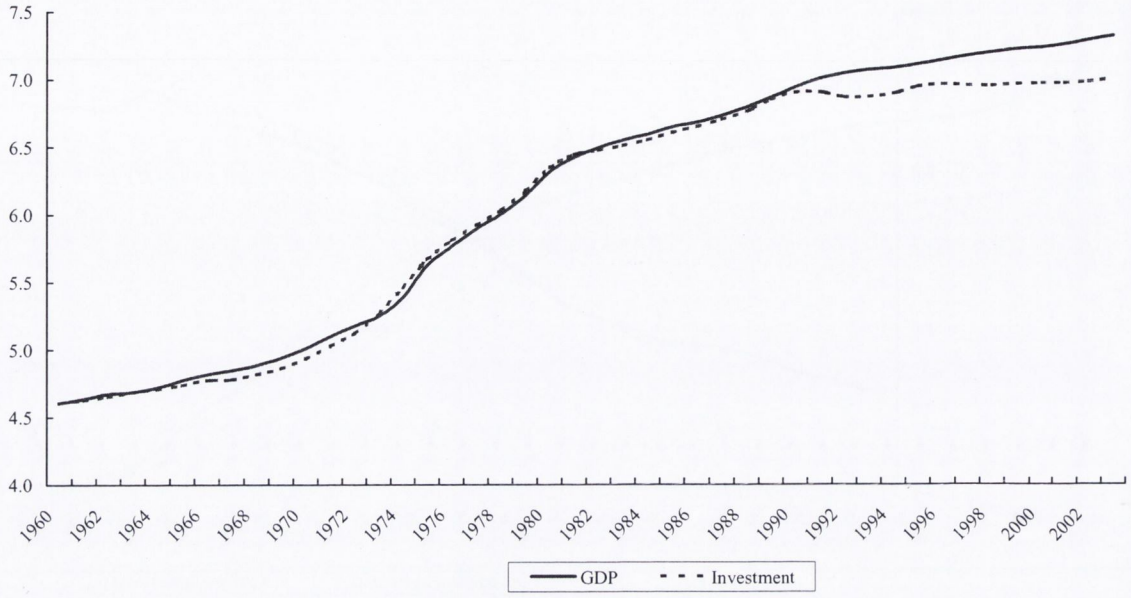


Chart 4.1sb UK Deflator Indices (log scale)

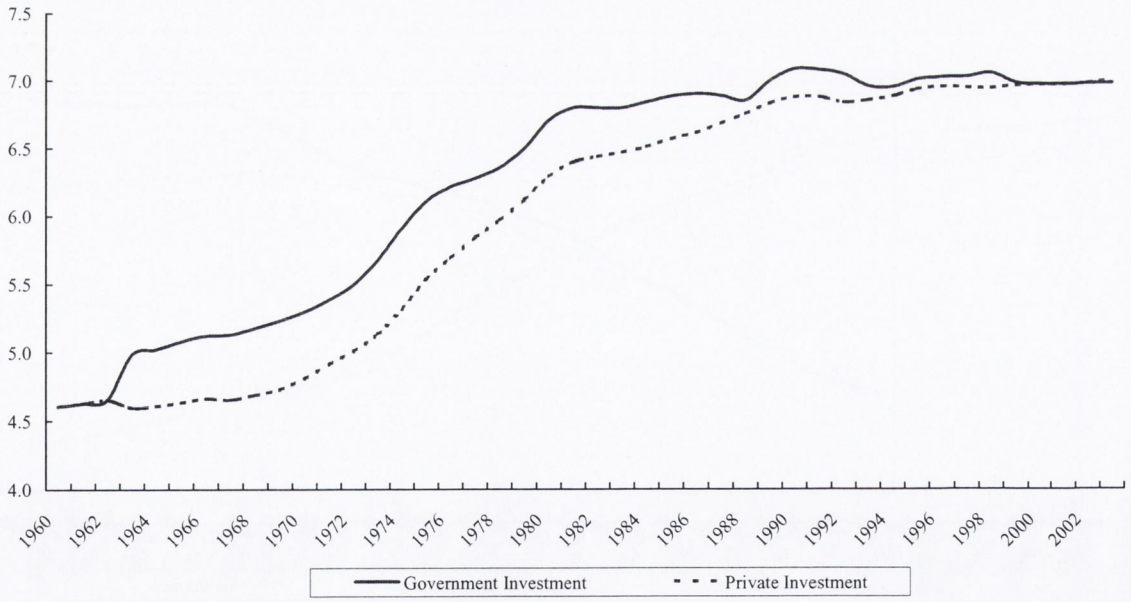


Chart 4.1sc UK Deflator Indices (log scale)

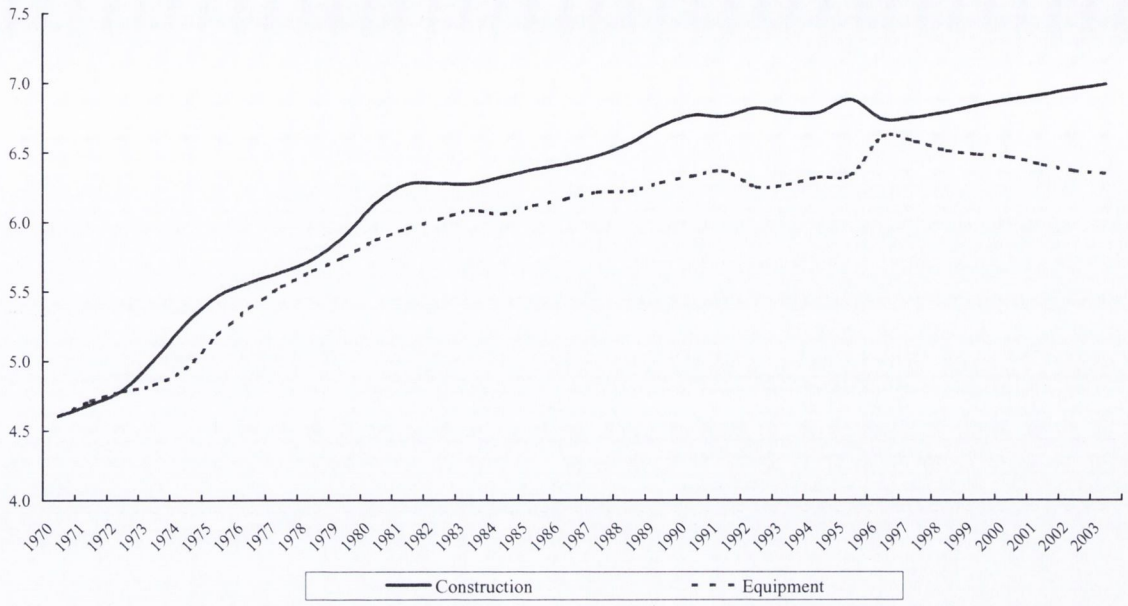


Chart 4.1ta US Deflator Indices (log scale)

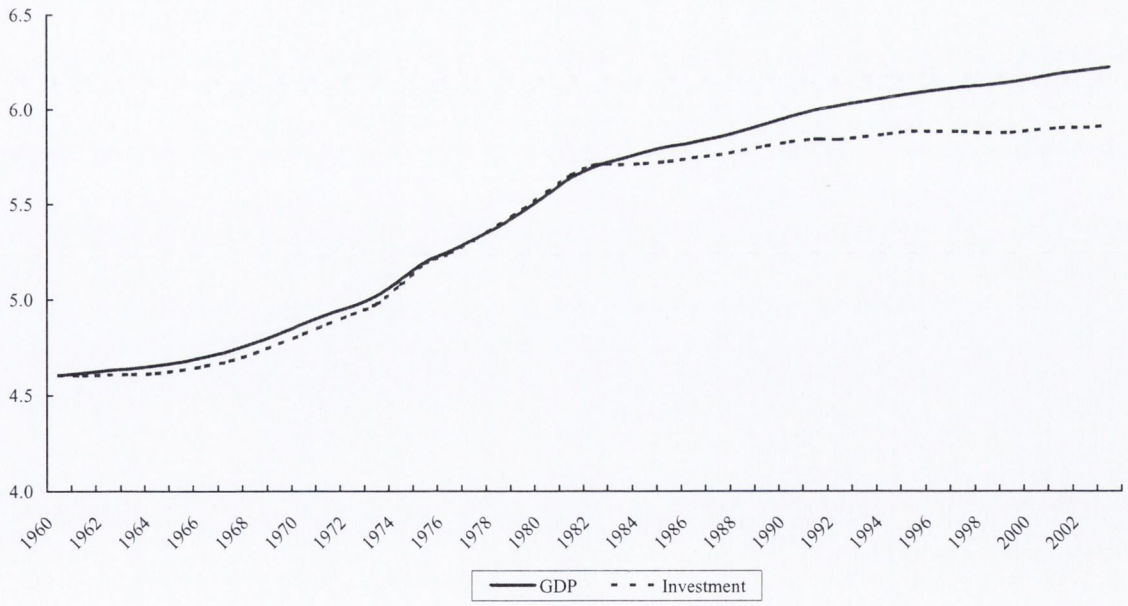


Chart 4.1tb US Deflator Indices (log scale)

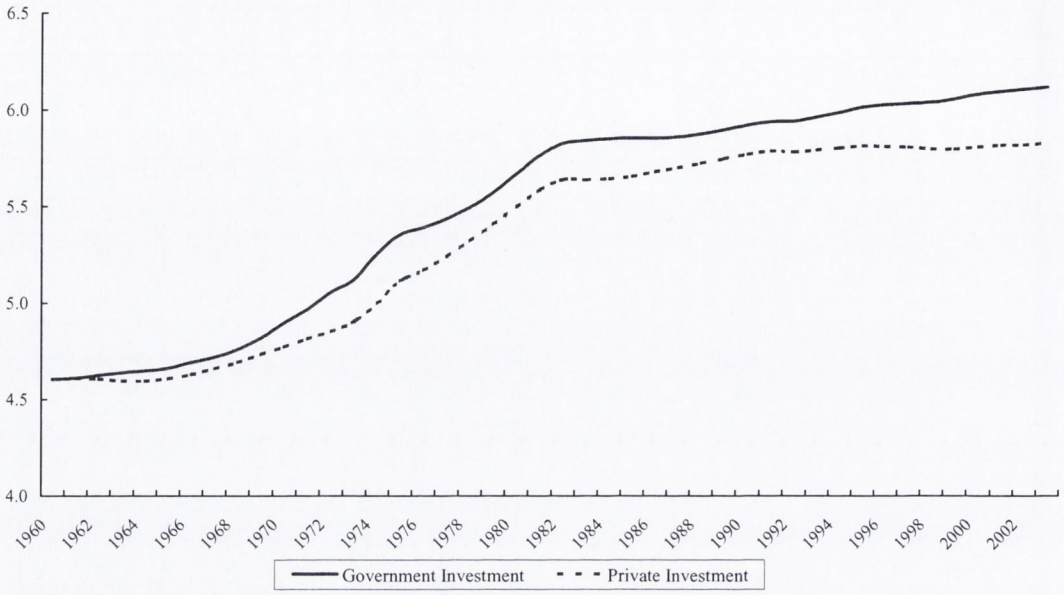


Chart 4.1tc US Deflator Indices (log scale)

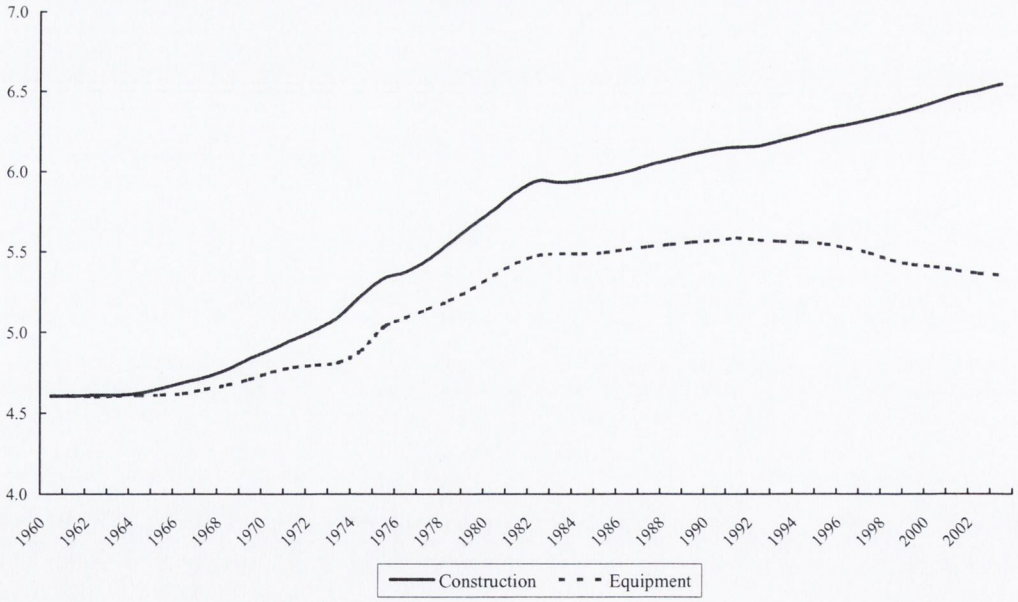


Table 4.1: Testing for Stationarity (Pool Unit Root Tests)

	ΔIp-ΔGDPp	**ΔGIp-ΔGDPp**	**ΔPIp-ΔGDPp**	**ΔCONp-ΔGDPp**	**ΔEQp-ΔGDPp**	**ΔGIp-ΔPIp**	**ΔCONp-ΔEQp**
Levin, Lin & Chu t test	-18.22	-18.91	-19.22	-17.49	-17.80	-17.12	-15.23
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ADF - Fisher Chi Square	334.00	357.71	357.89	297.51	299.79	365.36	256.66
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	$\Delta(I_t/K_{t-1})$	**$\Delta(GI_t/GK_{t-1})$**	**$\Delta(PI_t/PK_{t-1})$**	**ΔCONi**	**ΔEQi**	**$\Delta(GI_t/GK_{t-1})$-$\Delta(PI_t/PK_{t-1})$**	**ΔCONi-ΔEQi**
Levin, Lin & Chu t test	-18.71	-16.31	-19.26	-15.00	-19.00	-16.90	-19.96
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
ADF - Fisher Chi Square	324.55	294.41	338.33	245.74	299.79	365.34	363.71
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: *The values quoted relate to the Levin, Lin & Chu t and ADF-Fisher Chi Square Tests. The former test assumes a common unit root process while the latter assumes individual unit root processes. The null hypothesis is that a unit root is present, p values are in parentheses. Δ is the first difference operator, Ip is the log of the investment deflator index, GDPp is the log of the GDP deflator index, GIp is the log of the government investment deflator index, PIp is the log of the private investment deflator index, I is investment, K is the capital stock, GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, CONp is the log of the construction investment deflator index, EQp is the log of the equipment investment deflator index, ΔCONi is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment.*

Source: *OECD, AMECO database, own calculations and estimations*

Table 4.2a: Testing for Stationarity - Regressands (ERS Test)

	ΔIp-ΔGDPp	ΔGIp-ΔGDPp	ΔPIp-ΔGDPp	ΔCONIp-ΔGDPp	ΔEQp-ΔGDPp	ΔGIp-ΔPIp	ΔCONp-ΔEQp
Australia	1.00	1.48	1.29	See Notes	See Notes	2.00	See Notes
Austria	**17.80**	**7.77**	**6.37**	1.31	1.22	**18.02**	**14.64**
Belgium	1.15	1.99	1.12	0.02	1.11	2.19	1.10
Canada	1.75	1.55	1.86	1.33	2.18	1.37	1.13
Denmark	1.76	1.23	1.61	0.58	1.46	1.81	1.49
Finland	2.02	0.55	1.15	1.26	1.75	1.22	0.88
France	1.29	1.23	1.27	1.57	1.39	1.78	1.59
Germany	2.68	1.52	1.63	1.48	2.22	0.97	1.58
Greece	1.37	0.86	1.25	1.13	1.20	1.49	1.19
Ireland	1.34	1.42	1.39	1.38	1.63	1.49	**6.66**
Italy	1.29	1.26	1.15	1.39	1.32	**198.01**	1.60
Japan	1.00	0.90	1.00	0.52	2.04	3.40	1.94
Netherlands	3.09	1.36	0.68	0.01	2.56	1.96	3.66
New Zealand	1.70	1.22	1.22	See Notes	See Notes	2.64	See Notes
Norway	1.29	1.14	1.19	0.56	1.18	1.38	1.18
Portugal	1.40	See Notes	See Notes	See Notes	See Notes	See Notes	See Notes
Spain	1.42	1.17	1.24	1.41	1.43	3.51	1.81
Sweden	1.36	1.18	1.30	1.24	1.63	1.36	2.08
United Kingdom	0.70	1.14	1.06	1.12	1.19	1.13	1.13
United States	2.35	1.87	2.24	1.79	2.71	0.56	2.86
Critical values	1%	1.87					
	5%	2.97					
	10%	3.91					

Notes: *The values quoted relate to the Elliott-Rothenberg-Stock Point Optimal Unit Root Test. Δ is the first difference operator, Ip is the log of the investment deflator index, GDPp is the log of the GDP deflator index, GIp is the log of the government investment deflator index, PIp is the log of the private investment deflator index, CONp is the log of the construction investment deflator index, EQp is the log of the equipment investment deflator index. Separate deflators for private and government investment are unavailable for Portugal. Sufficient data observations on equipment and construction investment were not available for Australia, New Zealand and Portugal.*

Source: *OECD, AMECO database, own calculations and estimations*

Table 4.2b: Testing for Stationarity - Regressors (ERS Test)

	$\Delta(I_t/K_{t-1})$	$\Delta(GI_t/GK_{t-1})$	$\Delta(PI_t/PK_{t-1})$	$\Delta CONi$	ΔEQi	$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})$	$\Delta CONi-\Delta EQi$
Australia	0.49	1.29	0.43	See Notes	See Notes	1.52	See Notes
Austria	1.23	1.14	1.14	1.42	1.29	2.91	1.11
Belgium	1.43	1.15	1.15	1.23	1.11	0.73	1.12
Canada	1.25	1.19	1.19	1.35	1.60	1.58	1.31
Denmark	1.24	1.21	1.14	1.24	1.22	0.59	1.25
Finland	1.69	5.39	1.26	1.49	1.36	**129.53**	0.24
France	1.76	1.32	1.57	1.50	1.56	0.77	1.71
Germany	1.53	1.38	1.32	1.36	0.17	1.46	1.33
Greece	0.64	1.13	1.18	1.17	1.63	0.66	1.21
Ireland	1.90	1.14	1.11	1.45	1.27	1.51	1.21
Italy	1.01	1.65	0.45	0.64	1.36	2.02	1.41
Japan	3.00	1.33	0.41	1.50	0.72	**7.64**	1.61
Netherlands	1.43	1.21	1.29	1.38	1.25	0.63	1.34
New Zealand	1.65	1.13	1.36	See Notes	See Notes	0.55	See Notes
Norway	1.19	1.20	1.17	1.34	1.09	1.25	1.10
Portugal	1.70	See Notes	See Notes	See Notes	See Notes	See Notes	See Notes
Spain	1.12	1.15	0.87	1.11	1.51	1.17	1.38
Sweden	1.10	1.30	0.78	1.42	0.60	1.48	1.33
United Kingdom	1.40	1.78	1.38	1.44	0.47	2.14	3.14
United States	0.60	1.83	0.42	0.04	0.59	0.59	0.70
Critical values	1%	1.87					
	5%	2.97					
	10%	3.91					

Notes: *The values quoted relate to the Elliott-Rothenberg-Stock Point Optimal Unit Root Test. Δ is the first difference operator, I is investment, K is the capital stock, GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, $\Delta CONi$ is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment. Separate deflators for private and government investment are unavailable for Portugal. Sufficient data observations on equipment and construction investment were not available for Australia, New Zealand and Portugal.*

Source: *OECD, AMECO database, own calculations and estimations*

Table 4.3a: Total Investment Deflator/GDP Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.00	0.00	0.00	0.00
	(3.50)	(1.45)	(1.90)	(0.23)
$\Delta(I_t/K_{t-1})$	1.92***	25.43**	-	-
	(3.32)	(2.01)		
$\Delta(I_t/K_{t-1})\gamma 1$	-	-	-0.35	3.44
			(0.33)	(1.01)
$\Delta(I_t/K_{t-1})\gamma 2$	-	-	3.36***	15.31***
			(4.10)	(3.06)
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)$	-12.28***	-145.75**	-	-
	(4.17)	(2.10)		
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 1$	-	-	-0.91	-22.54
			(0.17)	(1.17)
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 2$	-	-	-19.27***	-84.22***
			(4.85)	(3.53)
AR(1)	0.29	0.30	0.29	0.29
	(8.91)	(8.00)	(8.88)	(8.33)
$RBAR^2$	0.10		0.11	
DW	1.99	1.95	2.00	2.00

Notes: *Pooled least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp-ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.3b: Total Investment Deflator/GDP Deflator (Fixed Cross Section Effects)				
	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.00	0.00	0.00	0.00
	(3.50)	(1.75)	(1.62)	(0.24)
$\Delta(I_t/K_{t-1})$	1.96***	20.94*	-	-
	(3.40)	(1.90)		
$\Delta(I_t/K_{t-1})\gamma 1$	-	-	-0.95	0.20
			(0.88)	(0.06)
$\Delta(I_t/K_{t-1})\gamma 2$	-	-	3.86***	16.84***
			(4.10)	(3.38)
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)$	-12.45***	-120.93**	-	-
	(4.23)	(2.00)		
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 1$	-	-	(2.01)	-3.18
			(0.37)	(0.87)
$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 2$	-	-	-21.53***	-92.25***
			(5.27)	(3.87)
AR(1)	0.27	0.29	0.26	0.24
	(7.90)	(7.67)	(7.73)	(7.01)
$RBAR^2$	0.10		0.11	
DW	1.99	1.95	1.99	2.00

Notes: *Pooled least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp-ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.4a: Government Investment Deflator/GDP Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	-0.003	-0.002	-0.002	0.06
	(1.86)	(1.47)	(1.17)	(1.68)
$\Delta(GI_t/GK_{t-1})$	-0.92	3.10	-	-
	(1.56)	(0.71)		
$\Delta(GI_t/GK_{t-1})\gamma 1$	-	-	-0.90	-58.09*
			(0.86)	(1.74)
$\Delta(GI_t/GK_{t-1})\gamma 2$	-	-	-0.99	14.52
			(1.13)	(0.87)
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)$	1.63	-19.54	-	-
	(0.54)	(0.90)		
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 1$	-	-	1.12	262.73
			(0.23)	(1.61)
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 2$	-	-	2.39	-19.39
			(0.54)	(0.34)
AR(1)	0.14	0.11	0.14	0.18
	(3.38)	(2.99)	(4.12)	(3.37)
$RBAR^2$	0.03		0.03	
DW	2.02	2.03	2.02	2.01

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp-\Delta GDPp$ is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. Independent variables: GI is government investment, GK is the government capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.4b: Government Investment Deflator/GDP Deflator (Fixed Cross Section Effects)				
	Symmetric OLS (1)	**Symmetric TSLS (2)**	**Asymmetric OLS (3)**	**Asymmetric TSLS (4)**
c	-0.003 (1.91)	-0.002 (1.47)	-0.002 (1.05)	0.013 (1.70)
$\Delta(GI_t/GK_{t-1})$	-0.91 (1.54)	2.54 (0.61)	-	-
$\Delta(GI_t/GK_{t-1})\gamma 1$	-	-	-1.05 (0.98)	-27.99 (1.63)
$\Delta(GI_t/GK_{t-1})\gamma 2$	-	-	-0.85 (0.95)	7.75 (1.06)
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)$	1.59 (0.52)	-18.52 (0.81)	-	-
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 1$	-	-	1.82 (0.35)	123.00 (1.40)
$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 2$	-	-	1.81 (0.40)	-11.44 (0.44)
AR(1)	0.12 (3.38)	0.09 (2.37)	0.12 (3.37)	0.12 (2.61)
$RBAR^2$	0.03		0.03	
DW	2.02	2.03	2.02	2.01

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. D is the first difference operator. Dependent variable: DGIp-DGDPp is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. Independent variables: GI is government investment, GK is the government capital stock, g1 is a dummy variable which takes a value of 1 when the relevant variable is positive, g2 is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.5a: Private Investment Deflator/GDP Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	-0.004	-0.003	-0.004	-0.018
	(3.70)	(1.74)	(2.74)	(1.77)
$\Delta(PI_t/PK_{t-1})$	1.25**	21.55*	-	-
	(2.46)	(1.90)		
$\Delta(PI_t/PK_{t-1})\gamma 1$	-	-	0.17	12.58**
			(0.19)	(2.30)
$\Delta(PI_t/PK_{t-1})\gamma 2$	-	-	1.92***	6.52
			(2.63)	(1.14)
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)$	-7.57***	-112.77*	-	-
	(3.04)	(1.95)		
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 1$	-	-	-1.43	-45.40**
			(0.33)	(2.06)
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 2$	-	-	-11.31***	-43.98*
			(3.32)	(1.82)
AR(1)	0.20	0.23	0.20	0.17
	(6.02)	(5.91)	(6.00)	(4.26)
$RBAR^2$	0.05		0.05	
DW	2.04	1.98	2.04	2.03

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔPIp-ΔGDPp is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. Independent variables: PI is private investment, PK is the private capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.5b: Private Investment Deflator/GDP Deflator (Fixed Cross Section Effects)				
	Symmetric OLS (1)	**Symmetric TSLS (2)**	**Asymmetric OLS (3)**	**Asymmetric TSLS (4)**
c	-0.004 (3.87)	-0.004 (3.17)	-0.004 (2.44)	-0.015 (1.64)
$\Delta(PI_t/PK_{t-1})$	1.32*** (2.62)	10.85** (2.48)	-	-
$\Delta(PI_t/PK_{t-1})\gamma 1$	-	-	-0.50 (0.54)	8.29** (2.02)
$\Delta(PI_t/PK_{t-1})\gamma 2$	-	-	2.53*** (3.40)	7.59 (1.51)
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)$	-7.84*** (3.17)	-52.59** (2.31)	-	-
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 1$	-	-	1.83 (0.41)	-26.75 (1.62)
$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 2$	-	-	-14.10*** (4.03)	-47.60** (2.28)
AR(1)	0.17 (4.87)	0.20 (6.70)	0.16 (4.75)	0.13 (3.44)
$RBAR^2$	0.06		0.06	
DW	2.03	2.07	2.03	2.03

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta PIp-\Delta GDPp$ is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. Independent variables: PI is private investment, PK is the private capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.6a: Construction Investment Deflator/GDP Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.004	0.001	0.003	-0.029
	(3.66)	(0.37)	(1.84)	(1.39)
$\Delta(CONi_t)$	-0.02	0.29*	-	-
	(0.41)	(1.90)		
$\Delta(CONi_t)\gamma 1$	-	-	0.04	-0.25
			(0.79)	(0.51)
$\Delta(CONi_t)\gamma 2$	-	-	-0.10	-2.88***
			(1.54)	(3.05)
$((CONi_t)^2-(CONi_{t-1})^2)$	0.003	-0.01	-	-
	(0.74)	(0.35)		
$((CONi_t)^2-(CONi_{t-1})^2))\gamma 1$	-	-	0.00	0.13**
			(0.03)	(2.50)
$((CONi_t)^2-(CONi_{t-1})^2))\gamma 2$	-	-	0.01	0.28***
			(1.25)	(2.59)
AR(1)		0.11		0.35
		(2.70)		(8.67)
$RBAR^2$	0.00		0.00	
DW	1.61	2.03	1.61	2.08

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: Δ CONp- Δ GDPp is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: CONi is the log of real construction investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.6b: Construction Investment Deflator/GDP Deflator (Fixed Cross Section Effects)

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.004	0.001	0.003	-0.012
	(3.71)	(0.62)	(1.98)	(0.98)
$\Delta(CONi_t)$	-0.03	0.19	-	-
	(0.82)	(1.08)		
$\Delta(CONi_t)\gamma 1$	-	-	0.01	-0.006
			(0.09)	(0.01)
$\Delta(CONi_t)\gamma 2$	-	-	-0.08	-1.87**
			(1.02)	(2.27)
$((CONi_t)^2-(CONi_{t-2})^2)$	0.003	0.00	-	-
	(1.06)	(0.17)		
$((CONi_t)^2-(CONi_{t-1})^2))\gamma 1$	-	-	0.00	0.05
			(0.42)	(1.01)
$((CONi_t)^2-(CONi_{t-1})^2))\gamma 2$	-	-	0.01	0.19*
			(0.81)	(1.89)
AR(1)		0.11		0.29
		(2.61)		(6.58)
$RBAR^2$	0.00		0.00	
DW	1.64	2.03	1.63	2.06

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔCONp- ΔGDPp is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: CONi is the log of real construction investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.7a: Equipment Investment Deflator/GDP Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	-0.005	-0.014	-0.018	-0.01
	(2.96)	(5.26)	(8.39)	(1.50)
$\Delta(EQi_t)$	-0.20***	0.06	-	-
	(5.73)	(0.52)		
$\Delta(EQi_t)\gamma 1$	-	-	-0.02	-0.02
			(0.53)	(0.12)
$\Delta(EQi_t)\gamma 2$	-	-	-0.46***	-0.09
			(6.80)	(0.14)
$((EQi_t)^2-(EQi_{t-1})^2)$	-0.01**	-0.01	-	-
	(2.02)	(0.69)		
$((EQi_t)^2-(EQi_{t-1})^2))\gamma 1$	-	-	-0.01*	-0.01
			(1.75)	(0.23)
$((EQi_t)^2-(EQi_{t-1})^2))\gamma 2$	-	-	0.00	0.02
			(0.50)	(0.20)
AR(1)		0.07		
		(1.94)		
$RBAR^2$	0.23		0.31	
DW	1.67	2.04	1.59	2.08

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔEQp-$\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: EQi is the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.7b: Equipment Investment Deflator/GDP Deflator (Fixed Cross Section Effects)

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	-0.005	-0.014	-0.019	-0.01
	(3.01)	(5.46)	(8.19)	(0.89)
$\Delta(EQi_t)$	-0.21***	0.07	-	-
	(5.43)	(0.37)		
$\Delta(EQi_t)\gamma 1$	-	-	0.01	-0.05
			(0.24)	(0.23)
$\Delta(EQi_t)\gamma 2$	-	-	-0.49***	-0.22
			(6.53)	(0.32)
$((EQi_t)^2-(EQi_{t-1})^2)$	-0.01	-0.01	-	-
	(1.52)	(0.37)		
$((EQi_t)^2-(EQi_{t-1})^2))\gamma 1$	-	-	-0.01*	-0.06
			(1.95)	(0.24)
$((EQi_t)^2-(EQi_{t-1})^2))\gamma 2$	-	-	0.00	0.06
			(0.09)	(0.53)
AR(1)		0.05		
		(1.18)		
$RBAR^2$	0.23		0.30	
DW	1.70	1.79	1.61	2.03

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta EQp-\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: EQi is the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.8a: Government Investment Deflator/ Private Investment Deflator

	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.00	0.00	0.00	0.00
	(1.20)	(1.09)	(0.26)	(0.67)
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})$	-0.36***	-0.51	-	-
	(3.18)	(1.11)		
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})\gamma 1$	-	-	-0.29	-0.83
			(1.62)	(1.09)
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})\gamma 2$	-	-	-0.38*	0.00
			(1.79)	(0.01)
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)$	-3.23	3.22	-	-
	(1.50)	(0.28)		
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)\gamma 1$	-	-	-8.70***	-14.16
			(2.95)	(0.71)
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)\gamma 2$	-	-	3.40	11.38
			(1.03)	(1.01)
AR(1)	0.02	0.03	0.03	-0.01
	(0.47)	(0.74)	(0.03)	(0.29)
$RBAR^2$	0.01		0.02	
DW	2.03	2.04	2.03	2.03

Notes: *Pooled least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp-\Delta PIp$ is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index . GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.8b: Government Investment Deflator/ Private Investment Deflator (Fixed Cross Section Effects)				
	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.00	0.00	0.00	0.00
	(1.27)	(1.18)	(0.09)	(0.69)
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})$	-0.35***	-0.58	-	-
	(3.13)	(1.13)		
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})\gamma 1$	-	-	-0.24	-0.64
			(1.27)	(0.49)
$\Delta(GI_t/GK_{t-1})-\Delta(PI_t/PK_{t-1})\gamma 2$	-	-	-0.45**	-0.08
			(2.08)	(0.92)
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)$	-3.48*	-1.03	-	-
	(1.69)	(0.08)		
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)\gamma 1$	-	-	-7.45**	-11.44
			(2.45)	(0.63)
$(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2-((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)\gamma 2$	-	-	1.16	11.29
			(0.34)	(0.30)
AR(1)	-0.03	-0.02	-0.03	-0.04
	(0.80)	(0.56)	(0.97)	(0.31)
$RBAR^2$	0.03		0.03	
DW	2.02	2.02	2.02	2.02

Notes: *Pooled and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp-\Delta PIp$ is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index . GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.9a: Construction Investment Deflator/Equipment Investment Deflator				
	Symmetric OLS (1)	Symmetric TSLS (2)	Asymmetric OLS (3)	Asymmetric TSLS (4)
c	0.013 (5.79)	0.013 (5.13)	0.022 (8.30)	0.004 (0.45)
$(\Delta CONi-\Delta EQi)$	-0.53*** (19.89)	-0.44*** (5.56)	-	-
$(\Delta CONi-\Delta EQi)\gamma 1$	-	-	-0.73*** (20.19)	-0.32* (1.77)
$(\Delta CONi-\Delta EQi)\gamma 2$	-	-	-0.20*** (3.88)	-0.70*** (3.39)
$(CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2$	0.11*** (7.98)	0.05 (1.19)	-	-
$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 1$	-	-	0.17*** (7.59)	0.07 (1.21)
$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 2$	-	-	0.01 (0.24)	0.13** (1.98)
AR(1)	0.30 (8.46)	0.28 (7.06)	0.31 (8.83)	0.28 (6.60)
$RBAR^2$	0.40		0.44	
DW	2.06	2.07	2.07	2.07

Notes: *Pooled ordinary and two-stage least squares regressions with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: Δ CONp- Δ EQp is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: Δ CONi is the change in the log of real construction investment, Δ EQi is the change in the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.9b: Construction Investment Deflator/Equipment Investment Deflator (Fixed Cross Section Effects)				
	Symmetric OLS (1)	**Symmetric TSLS (2)**	**Asymmetric OLS (3)**	**Asymmetric TSLS (4)**
c	0.013	0.012	0.021	0.007
	(5.92)	(5.20)	(8.16)	(0.86)
(ΔCONi-ΔEQi)	-0.53***	-0.43***	-	-
	(19.55)	(5.41)		
(ΔCONi-ΔEQi)γ1	-	-	-0.73***	-0.33**
			(19.46)	(2.22)
(ΔCONi-ΔEQi)γ2	-	-	-0.20***	-0.65***
			(3.83)	(3.48)
$(CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2$	0.11***	0.04	-	-
	(7.94)	(1.03)		
$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma$1	-	-	0.17***	0.05
			(7.21)	(0.74)
$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma$2	-	-	0.01	0.12
			(0.25)	(1.61)
AR(1)	0.28	0.26	0.30	0.25
	(7.83)	(6.44)	(8.45)	(5.84)
$RBAR^2$	0.39		0.43	
DW	2.05	2.06	2.06	2.06

Notes: *Pooled ordinary and two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔCONp- ΔEQp is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: ΔCONi is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment, γ1 is a dummy variable which takes a value of 1 when the relevant variable is positive, γ2 is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.10: Total Investment Deflator/GDP Deflator (OLS)

	c	$\Delta(I_t/K_{t-1})$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)$	AR(1)	$RBAR^2$	DW
Australia	-0.010	-0.60	-0.59		-0.01	2.01
	(4.72)	(0.07)	(0.01)			
Austria	-0.003	-6.75***	42.10***		0.11	1.89
	(1.92)	(3.78)	(4.30)			
Belgium	-0.002	-0.42	2.04		-0.05	1.86
	(0.72)	(0.08)	(0.06)			
Canada	-0.010	8.96***	-42.50***	0.26	0.16	1.83
	(2.89)	(3.53)	(3.40)	(1.79)		
Denmark	-0.008	1.07	-16.69	0.15	0.20	1.91
	(2.33)	(0.30)	(0.66)	(0.64)		
Finland	0.004	3.44	-8.05		0.26	1.92
	(1.30)	(0.87)	(0.30)			
France	-0.005	11.07***	-68.83***		0.14	2.06
	(2.97)	(3.92)	(3.90)			
Germany	-0.001	5.52	-25.23	0.31	0.30	1.80
	(0.40)	(0.93)	(0.66)	(1.95)		
Greece	0.006	2.49	-17.38	0.44	0.21	2.01
	(0.67)	(1.03)	(1.54)	(3.83)		
Ireland	0.005	11.05***	-59.92***	0.31	0.28	1.78
	(0.81)	(3.23)	(3.05)	(2.02)		
Italy	0.000	-5.58	41.15	0.37	0.07	1.97
	(0.02)	(0.49)	(0.51)	(2.29)		
Japan	-0.010	0.99	-4.26	0.42	0.14	1.85
	(2.62)	(0.47)	(0.55)	(2.30)		
Netherlands	-0.002	0.51	-8.16	0.19	0.04	1.81
	(0.64)	(0.13)	(0.30)	(1.66)		
New Zealand	-0.005	6.92	-44.64	0.17	-0.01	1.97
	(0.61)	(0.93)	(0.91)	(0.65)		
Norway	-0.001	8.06	-48.10	0.19	0.00	1.95
	(0.14)	(1.42)	(1.51)	(1.15)		
Portugal	-0.003	2.72	-16.37	0.44	0.16	1.97
	(0.36)	(0.90)	(1.12)	(2.94)		
Spain	-0.005	-2.48*	11.10	0.34	0.07	1.89
	(1.19)	(1.71)	(1.60)	(3.86)		
Sweden	-0.005	-0.10	4.00		-0.04	1.92
	(1.68)	(0.02)	(0.09)			
United Kingdom	-0.007	0.85	-2.97	0.47	0.17	1.66
	(1.08)	(0.10)	(0.06)	(2.96)		
United States	-0.007	-7.77***	43.06***	0.75	0.56	1.87
	(1.41)	(3.42)	(3.39)	(9.39)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp- ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.11: Total Investment Deflator/GDP Deflator (TSLS)

	c	$\Delta(I_t/K_{t-1})$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)$	AR(1)	DW
Australia	-0.009	0.12	-13.85		1.69
	(3.32)	(0.01)	(0.14)		
Austria	-0.004	-3.37	23.06		1.92
	(1.97)	(0.42)	(0.49)		
Belgium	-0.001	24.80	-153.10		2.00
	(0.47)	(0.46)	(0.44)		
Canada	-0.009	-8.73	62.67		1.78
	(1.28)	(0.11)	(0.15)		
Denmark	-0.006	-54.66	353.65		1.70
	(0.70)	(0.51)	(0.49)		
Finland	0.003	9.22*	-53.12	0.05	1.96
	(0.53)	(1.66)	(1.02)	(0.27)	
France	-0.005	7.83	-49.65	0.01	2.00
	(2.99)	(0.68)	(0.70)	(0.06)	
Germany	0.000	-25.50	191.44	0.11	1.88
	(0.01)	(0.76)	(0.84)	(0.52)	
Greece	0.007	6.17*	-36.56**	0.44	1.89
	(0.79)	(1.66)	(2.20)	(4.32)	
Ireland	0.003	36.61***	-188.66***	0.23	1.88
	(0.46)	(2.94)	(3.31)	(1.78)	
Italy	-0.001	6.66	-36.56	0.37	1.93
	(0.11)	(0.18)	(0.12)	(0.51)	
Japan	-0.013	-4.66	17.02	0.35	1.79
	(2.40)	(0.58)	(0.55)	(1.58)	
Netherlands	-0.001	32.73**	-230.99**	-0.22	1.94
	(0.39)	(2.31)	(2.32)	(0.88)	
New Zealand	-0.004	-5.35	19.95	0.22	1.94
	(0.56)	(0.21)	(0.12)	(0.69)	
Norway	0.006	-10.65	150.54		2.06
	(0.31)	(0.17)	(0.42)		
Portugal	-0.002	19.91	-109.82	0.36	1.82
	(0.23)	(0.64)	(0.74)	(1.77)	
Spain	-0.005	4.33	-23.39	0.32	1.83
	(1.34)	(0.66)	(0.72)	(2.43)	
Sweden	-0.005	31.28	-221.45		1.73
	(1.20)	(1.13)	(1.11)		
United Kingdom	-0.007	355.62	-2315.07		1.79
	(0.38)	(0.43)	(0.43)		
United States	-0.006	-16.52**	92.85**	0.68	1.86
	(1.33)	(2.30)	(2.02)	(7.37)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp- ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock and AR(1) is the first order autoregressive coefficient. The instrumental variables used are the trade-weighted averages of the relevant variables in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.12: Total Investment Deflator/GDP Deflator with Asymmetry (OLS)

	c	$\Delta(I_t/K_{t-1})\gamma 1$	$\Delta(I_t/K_{t-1})\gamma 2$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 1$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Australia	-0.008	-5.92	3.46	28.43	-22.93		-0.04	2.00
	(2.01)	(0.36)	(0.39)	(0.28)	(0.44)			
Austria	0.000	-13.94**	-3.06	76.59***	25.13*		0.10	1.90
	(0.10)	(2.36)	(1.10)	(2.68)	(1.88)			
Belgium	-0.004	-14.08	11.62*	90.43	-76.45*		0.02	2.14
	(1.37)	(1.55)	(1.82)	(1.54)	(1.84)			
Canada	-0.004	18.88***	9.11	-104.07***	-36.48		0.23	1.79
	(1.49)	(4.35)	(1.17)	(4.29)	(0.96)			
Denmark	-0.012	1.01	1.25	-9.03	-23.70	0.14	0.19	1.89
	(2.43)	(0.24)	(0.40)	(0.31)	(1.13)	(0.63)		
Finland	0.010	-6.73*	7.42**	49.53*	-29.73		0.33	1.87
	(1.98)	(1.76)	(2.26)	(1.85)	(1.20)			
France	-0.003	6.25*	16.24***	-44.68*	-95.76***		0.13	2.13
	(0.61)	(1.70)	(3.46)	(1.86)	(3.64)			
Germany	-0.003	-0.30	10.34*	15.78	-61.73*	0.37	0.30	1.77
	(0.78)	(0.02)	(1.98)	(0.17)	(1.98)	(2.23)		
Greece	0.011	-7.58**	11.21***	28.69**	-57.60***	0.45	0.30	1.92
	(1.35)	(2.48)	(3.51)	(2.47)	(3.94)	(3.42)		
Ireland	0.005	4.58	16.94***	-26.77*	-89.53***	0.32	0.29	1.83
	(0.72)	(1.38)	(3.38)	(1.73)	(3.17)	(2.35)		
Italy	-0.001	-20.62	0.45	130.01	5.38	0.32	0.04	1.96
	(0.34)	(1.68)	(0.03)	(1.62)	(0.05)	(2.01)		
Japan	-0.138	3.12	-0.06	-8.91	-1.50	0.49	0.11	1.88
	(2.12)	(0.77)	(0.02)	(0.59)	(0.15)	(2.65)		
Netherlands	0.000	5.75	0.25	-48.71	-0.80		0.04	1.75
	(0.51)	(1.03)	(0.08)	(1.42)	(0.04)			
New Zealand	-0.013	1.42	15.60*	-1.93	-108.89*		-0.01	1.89
	(0.97)	(0.13)	(1.82)	(0.03)	(2.01)			
Norway	0.008	-2.03	15.59*	2.94	-85.70*	0.16	-0.01	1.97
	(0.76)	(0.29)	(1.86)	(0.07)	(1.93)	(0.95)		
Portugal	-0.001	-7.93	8.87***	34.87	-45.10***	0.35	0.17	1.96
	(0.06)	(1.34)	(3.42)	(1.10)	(3.50)	(1.96)		
Spain	0.008	-2.54	0.15	-0.05	8.96	0.43	0.26	1.83
	(1.06)	(0.53)	(0.03)	(0.00)	(0.43)	(3.18)		
Sweden	-0.005	-11.68	6.40	84.17*	-42.33		-0.03	2.00
	(1.31)	(1.52)	(0.71)	(1.76)	(0.58)			
United Kingdom	0.001	-11.81	1.68	63.73	10.36	0.49	0.20	1.64
	(0.07)	(0.66)	(0.15)	(0.56)	(0.15)	(2.70)		
United States	-0.009	-3.39	-9.59***	16.62	53.95***	0.74	0.54	1.81
	(1.38)	(0.45)	(3.45)	(0.36)	(3.62)	(7.89)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp- ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.13: Total Investment Deflator/GDP Deflator with Asymmetry (TSLS)

	c	$\Delta(I_t/K_{t-1})\gamma 1$	$\Delta(I_t/K_{t-1})\gamma 2$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 1$	$((I_t/K_{t-1})^2-(I_{t-1}/K_{t-2})^2)\gamma 2$	AR(1)	DW
Australia	-0.023	-73.78***	11.94	488.61***	-95.27	0.32	1.94
	(2.38)	(2.85)	(0.92)	(2.92)	(1.34)	(2.00)	
Austria	-0.003	-8.13	-2.98	50.70	21.32		1.91
	(0.50)	(0.68)	(0.46)	(0.83)	(0.53)		
Belgium	0.003	-11.55	25.32***	78.75	156.51***	-0.21	2.07
	(0.66)	(1.07)	(3.51)	(1.14)	(3.33)	(1.40)	
Canada	-0.008	23.57**	3.36	-119.90**	8.93	-0.03	1.94
	(0.60)	(2.27)	(0.19)	(2.20)	(0.10)	(0.10)	
Denmark	0.002	-17.41	18.16*	106.96	-118.41	0.56	1.96
	(0.31)	(1.34)	(1.99)	(1.38)	(2.27)	(3.62)	
Finland	0.020	-11.35	15.16***	36.09	-79.24**	0.25	2.05
	(1.54)	(0.69)	(2.84)	(0.29)	(2.16)	(1.48)	
France	-0.002	3.05	20.23***	-23.53	-122.26***	-0.130	2.05
	(0.83)	(0.44)	(3.80)	(0.48)	(3.91)	(0.88)	
Germany	0.001	-26.75	23.31*	193.62	-147.16*	0.47	1.80
	(0.30)	(0.59)	(1.95)	(0.65)	(1.97)	(2.51)	
Greece	0.028	-14.65	23.12	60.39	-109	0.37	1.86
	(2.87)	(1.27)	(3.01)	(1.07)	(3.24)	(2.70)	
Ireland	-0.070	4.47	-22.46	25.76	56.62	0.13	1.98
	(0.59)	(0.08)	(0.26)	(0.07)	(0.16)	(0.54)	
Italy	0.011	-85.77**	41.81	515.79**	-265.94	0.06	1.98
	(0.86)	(2.61)	(1.45)	(2.63)	(1.49)	(0.51)	
Japan	0.009	-2.92	14.02	-9.19	-51.83	0.24	1.85
	(0.39)	(0.37)	(0.73)	(0.34)	(0.75)	(1.57)	
Netherlands	0.003	37.56**	18.76***	-252.29**	-138.95***	-0.20	1.95
	(0.38)	(2.12)	(2.69)	(2.37)	(2.92)	(0.76)	
New Zealand	-0.036	-5.22	-8.46	-67.19	-92.51	-0.04	2.00
	(1.80)	(0.18)	(0.31)	(0.35)	(0.55)	(0.10)	
Norway	0.044	-2.25	38.35	-33.25	162.79	0.23	2.10
	(1.09)	(0.08)	(1.00)	(0.18)	(0.91)	(1.09)	
Portugal	0.010	-22.23	6.39	81.39	-40.00	0.46	1.75
	(0.54)	(0.31)	(0.65)	(0.44)	(0.55)	(2.08)	
Spain	0.004	10.48*	-4.49	-58.22**	30.84	0.63	1.92
	(0.39)	(1.72)	(0.42)	(2.12)	(0.65)	(4.76)	
Sweden	-0.030	-0.10	30.62*	56.12	-267.09*	0.09	2.01
	(1.57)	0.00	(1.79)	(0.37)	(1.78)	(0.94)	
United Kingdom	-0.020	86.75	151.00	-541.25	1023.98	0.10	1.97
	(1.25)	(1.27)	(1.57)	(1.27)	(1.60)	(0.82)	
United States	-0.007	-19.59*	-12.79*	121.54*	69.47*	0.73	1.68
	(1.91)	(1.91)	(1.89)	(1.98)	(1.70)	(8.49)	

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔIp- ΔGDPp is the change in the log of the investment deflator index minus the change in the log of the GDP deflator index. Independent variables: I is investment, K is the capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. The instrumental variables are the trade weighted averages of the relevant variable in the particular country's tradeing partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.14: Government Investment Deflator/GDP Deflator (OLS)

	c	$\Delta(GI_t/GK_{t-1})$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)$	AR(1)	$RBAR^2$	DW
Australia	-0.006	-4.80	39.13	0.40	0.13	1.79
	(0.94)	(0.79)	(0.87)	(3.12)		
Austria	-0.006	0.59	-20.01***	0.21	0.26	2.02
	(0.16)	(0.73)	(2.69)	(1.51)		
Belgium	-0.013	3.91***	-22.95***	0.72	0.54	1.98
	(0.93)	(3.38)	(3.98)	(6.69)		
Canada	-0.010	-5.25	41.22	0.30	0.02	1.97
	(2.35)	(0.56)	(0.63)	(2.50)		
Denmark	0.000	-9.43***	52.66***	-0.31	0.19	1.96
	(0.04)	(3.97)	(3.25)	(1.28)		
Finland	-0.004	3.32*	-16.32*	0.18	0.05	1.89
	(0.74)	(1.75)	(2.00)	(1.38)		
France	0.000	8.85*	-56.39*	0.43	0.09	2.09
	(0.00)	(1.80)	(1.70)	(2.51)		
Germany	-0.004	-0.48	12.97	0.54	0.32	1.79
	(0.60)	(0.21)	(0.79)	(4.69)		
Greece	-0.003	-2.45	0.85		0.17	2.19
	(0.50)	(0.90)	(0.06)			
Ireland	0.013	1.36	-4.40		-0.03	1.89
	(1.94)	(0.43)	(0.22)			
Italy	0.001	22.69*	-205.33**	0.14	0.54	1.97
	(0.11)	(2.00)	(2.34)	(1.24)		
Japan	-0.005	0.51	-7.23**	0.55	0.50	1.54
	(1.07)	(0.58)	(2.01)	(6.19)		
Netherlands	0.004	3.27	-25.03	0.25	0.07	1.84
	(1.33)	(1.15)	(1.47)	(1.17)		
New Zealand	-0.005	(2.26)	15.11	0.26	0.01	1.94
	(0.69)	(1.11)	(0.98)	(1.65)		
Norway	-0.007	12.77**	-64.28**		0.13	2.01
	(1.68)	(2.11)	(2.02)			
Spain	0.006	-1.72	8.73	0.13	-0.04	1.75
	(1.25)	(1.24)	(1.36)	(0.63)		
Sweden	-0.010	-6.27*	33.01*	0.22	0.04	1.89
	(1.70)	(1.81)	(2.01)	(2.23)		
United Kingdom	-0.008	6.55	-56.81	0.22	-0.02	1.97
	(0.58)	(1.07)	(1.20)	(2.00)		
United States	-0.003	-7.12	46.71	0.56	0.40	2.14
	(0.60)	(1.59)	(1.53)	(4.40)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔGIp-ΔGDPp is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. Independent variables: GI is government investment, GK is the government capital stock and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.15: Government Investment Deflator/GDP Deflator (TSLS)

	c	$\Delta(GI_t/GK_{t-1})$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)$	AR(1)	DW
Australia	-0.005	-5.35	22.93	0.29	1.83
	(0.69)	(0.11)	(0.09)	(1.14)	
Austria	0.003	12.71	-105.79	0.19	1.95
	(0.59)	(1.11)	(1.26)	(1.19)	
Belgium	-0.012	3.49	-18.65	0.70	2.06
	(0.98)	(1.26)	(1.33)	(4.76)	
Canada	-0.009	-123.81	823.87		2.01
	(1.61)	(0.37)	(0.37)		
Denmark	0.000	-10.89***	59.19*	-0.31	1.98
	(0.08)	(2.80)	(2.01)	(1.37)	
Finland	-0.006	-17.96	82.71	-0.07	2.03
	(0.90)	(1.26)	(1.30)	(0.39)	
France	0.002	-164.90	1248.27		1.88
	(0.01)	(0.13)	(0.13)		
Germany	-0.006	-4.86	37.48	0.57	1.66
	(0.76)	(1.40)	(1.64)	(5.34)	
Greece	-0.004	-23.58*	156.60*	-0.27	2.24
	(0.57)	(1.74)	(1.77)	(1.92)	
Ireland	0.011	-11.43	110.68	0.09	-2.09
	(1.05)	(0.61)	(0.70)	(0.35)	
Italy	0.001	24.24**	-218.28***	0.14	1.98
	(0.10)	(0.21)	(2.67)	(1.31)	
Japan	0.006	12.18	-52.63	0.47	1.83
	(0.06)	(1.23)	(1.37)	(2.87)	
Netherlands	0.004	-90.30	620.52		2.06
	(0.34)	(0.60)	(0.59)		
New Zealand	0.000	14.25	-329.55		1.62
	(0.20)	(0.25)	(0.32)		
Norway	-0.007	35.38***	-199.69***	-0.23	2.09
	(1.67)	(3.16)	(2.96)	(1.49)	
Spain	0.006	-6.92	26.68	0.12	1.83
	(0.91)	(0.28)	(0.24)	(0.36)	
Sweden	-0.012	-11.03	49.45	0.22	1.83
	(1.48)	(0.73)	(0.69)	(1.95)	
United Kingdom	-0.008	19.77	-158.17	0.29	1.94
	(0.55)	(0.68)	(0.74)	(2.62)	
United States	-0.004	25.52	-252.12	0.33	1.81
	(0.76)	(0.63)	(0.72)	(2.49)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp-\Delta GDPp$ is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. Independent variables: GI is government investment, GK is the government capital stock and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.16: Government Investment Deflator/GDP Deflator with Asymmetry (OLS)

	c	$\Delta(GI_t/GK_{t-1})\gamma 1$	$\Delta(GI_t/GK_{t-1})\gamma 2$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 1$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Australia	0.000	-11.25	2.38	75.21	-1.50	0.40	0.11	1.79
	(0.04)	(1.23)	(0.21)	(1.10)	(0.02)	(3.20)		
Austria	0.002	0.49	0.32	-27.40	-13.38	0.31	0.25	2.00
	(0.37)	(0.14)	(0.32)	(1.41)	(1.56)	(1.62)		
Belgium	-0.007	1.57	5.03***	-15.51	-25.37***	0.76	0.54	1.87
	(0.43)	(0.52)	(2.99)	(1.05)	(2.73)	(9.14)		
Canada	-0.011	-24.62***	25.58*	179.24***	-175.71*	0.43	0.03	1.91
	(1.11)	(2.99)	(1.84)	(3.00)	(1.81)	(4.42)		
Denmark	-0.003	-9.05**	-8.79**	57.86**	41.05	-0.31	0.16	1.97
	(0.38)	(2.06)	(2.51)	(2.50)	(1.53)	(1.29)		
Finland	0.005	1.24	4.34	-9.99	-16.74		0.09	1.90
	(0.89)	(0.49)	(1.37)	(0.86)	(1.16)			
France	0.001	4.67	14.99	-29.95	-95.45	0.44	0.05	2.07
	(0.23)	(0.61)	(1.46)	(0.54)	(1.43)	(2.34)		
Germany	-0.001	0.26	-2.29	3.44	31.01	0.54	0.31	1.78
	(0.07)	(0.09)	(0.53)	(0.15)	(1.31)	(4.96)		
Greece	0.007	-3.25	-3.82	-3.14	17.29	-0.16	0.15	1.98
	(0.42)	(0.72)	(0.73)	(0.18)	(0.66)	(1.03)		
Ireland	0.001	8.14*	-0.79	-33.79*	0.76		0.00	2.00
	(0.09)	(1.67)	(0.20)	(1.83)	(0.03)			
Italy	-0.005	17.75	30.15***	-158.15	-269.73***	0.17	0.54	1.94
	(0.66)	(0.96)	(3.88)	(1.13)	(4.50)	(1.06)		
Japan	-0.008	0.70	-0.55	-5.58	-4.63	0.58	0.51	1.46
	(1.44)	(0.77)	(0.39)	(1.32)	(0.88)	(6.30)		
Netherlands	0.003	4.26	2.64	-29.80	-21.95	0.251	0.02	1.84
	(0.57)	(0.95)	(0.56)	(1.28)	(0.72)	(1.16)		
New Zealand	-0.003	-9.96***	3.98*	70.04***	-29.97**	0.20	0.09	1.94
	(0.38)	(3.03)	(1.99)	(2.86)	(2.34)	(1.30)		
Norway	0.000	7.60	16.72**	-44.36	-78.81**		0.12	2.07
	(0.06)	(0.73)	(2.23)	(0.83)	(2.11)			
Spain	0.010	-0.59	-2.77**	-0.05	16.75		-0.05	1.80
	(1.44)	(0.31)	(2.15)	(0.01)	(3.03)			
Sweden	-0.011	-5.72	-6.70*	30.38	35.06**	0.22	-0.01	1.89
	(1.52)	(0.93)	(2.00)	(1.00)	(2.11)	(2.11)		
United Kingdom	-0.002	2.53	10.30	-31.40	-79.60	0.20	-0.07	1.96
	(0.08)	(0.26)	(1.47)	(0.47)	(1.49)	(2.09)		
United States	-0.005	3.82	-14.89**	-28.61	98.48**	0.54	0.41	2.08
	(1.11)	(0.27)	(2.66)	(0.29)	(2.24)	(5.11)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp-\Delta GDPp$ is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. GI is government investment, GK is the government capital stock, , $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive. $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.17: Government Investment Deflator/GDP Deflator with Asymmetry (TSLS)

	c	$\Delta(GI_t/GK_{t-1})\gamma 1$	$\Delta(GI_t/GK_{t-1})\gamma 2$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 1$	$((GI_t/GK_{t-1})^2-(GI_{t-1}/GK_{t-2})^2)\gamma 2$	AR(1)	DW
Australia	-0.043	78.96	53.38	-487.31	-442.24	-0.06	2.02
	(0.79)	(0.53)	(0.46)	(0.52)	(0.50)	(0.36)	
Austria	0.004	3.38	11.62	-44.61	-93.23	0.22	1.97
	(0.47)	(0.25)	(1.15)	(0.56)	(1.33)	(1.22)	
Belgium	-0.010	-2.58	5.12*	8.06	-27.82*	0.78	2.00
	(0.63)	(0.74)	(1.81)	(0.51)	(1.90)	(6.66)	
Canada	-0.027	-10.93	-61.17	97.08	375.92	-0.04	2.02
	(2.06)	(0.43)	(1.04)	(0.52)	(0.99)	(0.23)	
Denmark	0.005	-18.98	-4.37	108.14	12.62	-0.32	1.96
	(0.39)	(1.36)	(0.80)	(1.45)	(0.33)	(1.47)	
Finland	0.019	-9.01	3.60	31.92	-7.69	-0.08	2.00
	(1.21)	(0.77)	(0.34)	(0.67)	(0.18)	(0.44)	
France	-0.003	-10.36	20.02	81.93	-152.48	0.37	1.96
	(0.32)	(0.85)	(1.31)	(1.12)	(1.31)	(1.94)	
Germany	0.257	-246.72	81.31	1131.87	-171.89		1.93
	(0.08)	(0.09)	(0.09)	(0.08)	(0.10)		
Greece	0.044	-23.51	0.52	69.81	-6.74		2.16
	(6.62)	(0.61)	(0.04)	(0.29)	(0.08)		
Ireland	0.110	26.49	17.30	-258.64	-20.65	0.32	1.95
	(1.10)	(0.33)	(0.71)	(0.65)	(0.18)	(0.99)	
Italy	-0.009	-28.88	44.21	179.19	-378.61	0.29	1.87
	(0.42)	(0.45)	(1.21)	(0.43)	(1.47)	(1.19)	
Japan	-0.008	4.17	5.33	-18.53	-31.45	0.53	1.71
	(1.14)	(0.78)	(1.06)	(0.79)	(1.64)	(2.81)	
Netherlands	0.023	-42.95	7.53	242.47	-34.26	0.07	1.92
	(1.84)	(1.27)	(0.59)	(1.14)	(0.41)	(0.40)	
New Zealand							
Norway	-0.003	-23.94	-7.87	134.50	54.98	0.22	1.84
	(0.15)	(1.05)	(0.59)	(1.14)	(0.77)	(2.03)	
Spain	0.011	1.36	-6.66	-12.30	36.63	0.10	1.78
	(0.99)	(0.28)	(0.94)	(0.55)	(1.12)	(0.50)	
Sweden	-0.018	-11.97	-8.46	60.11	25.36	0.18	1.89
	(1.69)	(0.97)	(1.51)	(1.10)	(0.86)	(1.78)	
United Kingdom	0.005	-43.11	-2.15	374.13	61.67	0.03	1.98
	(0.14)	(1.33)	(0.11)	(1.51)	(0.32)	(0.21)	
United States	-0.008	26.21	-21.39*	-177.43	152.49	0.65	1.96
	(0.89)	(1.10)	(1.70)	(1.01)	(1.45)	(5.37)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: Δ Glp- Δ GDPp is the change in the log of the government investment deflator index minus the change in the log of the GDP deflator index. GI is government investment, GK is the government capital stock, , $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.18: Private Investment Deflator/GDP Deflator (OLS)

	c	$\Delta(PI_t/PK_{t-1})$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)$	AR(1)	$RBAR^2$	DW
Australia	-0.010	-2.81	14.45		-0.02	1.87
	(4.43)	(0.33)	(0.29)			
Austria	-0.005	-3.29*	21.15**		0.05	1.96
	(3.10)	(1.82)	(2.11)			
Belgium	-0.001	-11.97**	72.70**	0.25	0.03	1.99
	(0.28)	(2.59)	(2.67)	(2.85)		
Canada	-0.010	6.21***	-26.90***	0.30	0.18	1.83
	(2.70)	(3.75)	(3.51)	(1.99)		
Denmark	-0.007	3.74	-28.95	0.20	0.19	2.00
	(2.20)	(1.11)	(1.37)	(1.02)		
Finland	0.003	3.28	-10.81		0.21	1.95
	(1.04)	(0.94)	(0.45)			
France	-0.006	10.28***	-62.23***		0.20	2.05
	(3.55)	(4.56)	(4.59)			
Germany	-0.001	2.41	-6.96	0.30	0.27	1.80
	(0.33)	(0.59)	(0.29)	(1.82)		
Greece	0.009	3.65**	-20.99***	0.42	0.17	2.09
	(1.08)	(2.38)	(2.84)	(3.62)		
Ireland	0.004	6.15**	-32.14**	0.22	0.17	1.91
	(0.73)	(2.37)	(2.16)	(1.20)		
Italy	-0.002	-8.13	47.72	0.19	0.01	2.01
	(0.35)	(0.83)	(0.73)	(0.77)		
Japan	-0.015	0.12	-0.09	0.46	0.13	1.77
	(2.69)	(0.12)	(0.03)	(3.38)		
Netherlands	-0.003	1.38	-14.85		0.04	1.84
	(1.29)	(0.25)	(0.41)			
New Zealand	-0.005	6.93*	-40.02*	0.12	0.01	1.99
	(0.70)	(1.78)	(1.70)	(0.59)		
Norway	-0.001	4.58	-26.44	0.23	0.01	1.97
	(0.12)	(1.01)	(1.03)	(1.59)		
Spain	-0.004	-2.34	7.76	-0.36	0.07	2.12
	(1.11)	(0.54)	(0.41)	(1.60)		
Sweden	-0.004	0.90	-5.46		-0.05	1.81
	(1.35)	(0.22)	(0.18)			
United Kingdom	-0.007	3.09	-13.87	0.52	0.24	1.85
	(0.98)	(0.30)	(0.23)	(4.49)		
United States	-0.008	-5.49***	27.22***	0.70	0.51	1.85
	(1.86)	(3.22)	(3.10)	(7.10)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta PIp-\Delta GDPp$ is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. Independent variables: PI is private investment, PK is the private sector capital stock and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.19: Private Investment Deflator/GDP Deflator (TSLS)

	c	$\Delta(PI_t/PK_{t-1})$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)$	AR(1)	DW
Australia	-0.010	-0.23	-11.88	0.23	1.90
	(2.71)	(0.02)	(0.17)	(2.26)	
Austria	-0.004	37.86	-208.89		2.01
	(1.23)	(1.07)	(0.98)		
Belgium	0.002	161.23	-965.52		1.88
	(0.06)	(0.54)	(0.56)		
Canada	-0.009	-41.46	257.39		2.00
	(0.71)	(0.37)	(0.41)		
Denmark	-0.007	3.38	-31.39	0.13	1.95
	(1.76)	(0.15)	(0.15)	(0.11)	
Finland	0.002	11.91*	-76.68	0.07	1.98
	(0.48)	(1.86)	(1.31)	(0.40)	
France	-0.006	16.62	-114.69		1.94
	(2.49)	(1.89)	(1.60)		
Germany	0.000	1.05	20.03	0.18	1.89
	(0.02)	(0.00)	(0.01)	(0.04)	
Greece	0.011	4.35	-34.10	0.40	1.84
	(1.00)	(0.36)	(0.77)	(1.80)	
Ireland	0.003	21.67**	-106.07**	0.13	1.92
	(0.59)	(2.29)	(2.41)	(0.85)	
Italy	-0.001	25.23	-145.29	0.18	1.98
	(0.11)	(0.40)	(0.32)	(0.39)	
Japan	-0.015	0.16	-3.18	0.32	1.78
	(2.94)	(0.04)	(0.27)	(1.78)	
Netherlands	-0.003	-8.52	63.66	0.24	1.87
	(0.79)	(1.26)	(1.62)	(1.03)	
New Zealand	-0.005	641.46	-3609.99		1.80
	(0.05)	(0.16)	(0.16)		
Norway	-0.003	14.34	-109.27	0.27	1.93
	(0.30)	(1.09)	(1.23)	(1.71)	
Spain	-0.003	-15.09***	65.35***	-0.27	2.07
	(0.54)	(3.69)	(3.49)	(1.11)	
Sweden	-0.003	-22.15	175.99		2.00
	(0.46)	(0.84)	(0.75)		
United Kingdom	-0.007	151.44	-917.50	0.06	1.98
	(0.86)	(1.49)	(1.46)	(0.34)	
United States	-0.007	-13.07*	64.91	0.64	1.83
	(1.41)	(1.71)	(1.53)	(4.47)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔPIp- ΔGDPp is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. Independent variables: PI is private investment, PK is the private sector capital stock and AR(1) is the first order autoregressive coefficient.. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.20: Private Investment Deflator/GDP Deflator with Asymmetry (OLS)

	c	$\Delta(PI_t/PK_{t-1})\gamma 1$	$\Delta(PI_t/PK_{t-1})\gamma 2$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 1$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Australia	-0.005	-9.52	2.34	45.70	-10.86		0.00	1.86
	(1.03)	(0.55)	(0.27)	(0.43)	(0.22)			
Austria	-0.005	-2.83	-3.36	19.45	20.93		0.00	1.95
	(1.69)	(0.90)	(1.10)	(1.31)	(1.28)			
Belgium	-0.001	18.02*	-1.95	111.34*	12.94		0.03	1.90
	(0.14)	(1.81)	(0.37)	(1.86)	(0.39)			
Canada	-0.004	13.05***	7.49	-68.81***	-27.57	0.07	0.24	1.85
	(1.44)	(3.50)	(1.66)	(3.32)	(1.37)	(0.40)		
Denmark	-0.011	3.80	3.71	-25.50	-32.89	0.21	0.18	1.99
	(2.48)	(1.19)	(0.99)	(1.23)	(1.53)	(1.14)		
Finland	0.007	-5.40	7.33**	43.36*	-36.14		0.27	1.88
	(1.39)	(1.61)	(2.27)	(1.87)	(1.49)			
France	-0.002	5.42	15.87***	-41.60**	-90.01***	-0.07	0.20	2.03
	(0.69)	(1.59)	(3.59)	(2.02)	(3.82)	(0.60)		
Germany	-0.005	10.91	2.17	-51.51	-12.61	0.30	0.32	1.83
	(1.77)	(1.45)	(0.50)	(1.19)	(0.52)	(1.73)		
Greece	0.008	-1.85	7.24***	9.67	-38.63***	0.32	0.23	2.00
	(0.79)	(0.66)	(2.97)	(0.90)	(3.62)	(2.70)		
Ireland	0.000	3.14	8.21**	-14.84	-43.82**	0.21	0.18	1.91
	(0.02)	(1.01)	(2.32)	(1.13)	(2.39)	(1.18)		
Italy	0.005	-31.42**	9.21	183.75**	-52.18	0.15	0.08	1.98
	(0.67)	(2.54)	(0.83)	(2.44)	(0.72)	(0.79)		
Japan	-0.014	0.05	0.20	-0.19	-0.20	0.45	0.09	1.78
	(2.44)	(0.02)	(0.14)	(0.02)	(0.04)	(3.05)		
Netherlands	-0.001	4.52	-0.30	-38.81	-0.22		0.02	1.94
	(0.15)	(0.58)	(0.06)	(0.77)	(0.01)			
New Zealand	-0.016	9.08	7.51	-42.39	-52.31		0.01	2.01
	(1.49)	(1.17)	(1.27)	(1.02)	(1.51)			
Norway	0.006	-2.86	10.36	10.96	-55.82	0.22	0.01	1.96
	(0.60)	(0.44)	(1.54)	(0.31)	(1.53)	(1.40)		
Spain	0.015	-7.58	7.94*	19.00	-25.00	-0.44	0.14	2.11
	(1.81)	(1.13)	(1.86)	(0.62)	(1.63)	(2.04)		
Sweden	-0.006	-10.19**	6.49	75.71**	-46.79		-0.01	1.94
	(1.68)	(2.02)	(1.25)	(2.15)	(1.36)			
United Kingdom	-0.002	-5.57	7.26	29.65	-28.22	0.48	0.23	1.95
	(0.18)	(0.48)	(0.43)	(0.45)	(0.29)	(4.03)		
United States	-0.011	-3.69	-7.30***	20.10	35.43***	0.70	0.51	1.62
	(2.56)	(1.60)	(2.83)	(1.43)	(2.77)	(6.10)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: Δ PIp- Δ GDPp is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. PI is private investment, PK is the private capital stock , $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.21: Private Investment Deflator/GDP Deflator with Asymmetry (TSLS)

	c	$\Delta(PI_t/PK_{t-1})\gamma 1$	$\Delta(PI_t/PK_{t-1})\gamma 2$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 1$	$((PI_t/PK_{t-1})^2-(PI_{t-1}/PK_{t-2})^2)\gamma 2$	AR(1)	DW
Australia	-0.012	-49.78***	7.80	306.25***	-51.57	0.30	1.96
	(1.08)	(2.94)	(0.90)	(2.83)	(0.86)	(1.89)	
Austria	-0.006	48.41	7.37	-263.01	-36.79		1.97
	(0.54)	(1.25)	(0.40)	(1.16)	(0.38)		
Belgium	-0.003	-27.76	-30.81	150.88	169.50	0.47	1.95
	(0.27)	(1.17)	(1.43)	(1.00)	(1.35)	(1.91)	
Canada	-0.006	12.64	5.62	-60.76	-16.78	0.05	1.88
	(0.28)	(0.45)	(0.25)	(0.35)	(0.16)	(0.07)	
Denmark	-0.001	6.26	-4.41	-61.82	20.88	0.06	1.95
	(0.05)	(0.79)	(0.45)	(1.47)	(0.33)	(0.44)	
Finland	0.000	-0.65	8.70**	24.42	-52.23*	0.00	1.97
	(0.05)	(0.06)	2.48	0.31	(1.87)	(0.02)	
France	-0.012	21.01	10.01	-110.67	-69.62		2.02
	(2.44)	(0.54)	(0.75)	(0.50)	(0.84)		
Germany	-0.006	19.16	3.10	-92.91	-11.61	0.21	1.90
	(1.10)	(1.03)	(0.27)	(0.78)	(0.18)	(0.87)	
Greece	0.022	27.74	52.15	-153.53	-258.85		1.86
	(0.33)	(0.33)	(0.74)	(0.38)	(0.85)		
Ireland	-0.007	29.46*	18.78	-137.24*	-97.22	0.14	1.91
	(0.38)	(1.67)	(1.10)	(1.68)	(1.38)	(1.05)	
Italy	-0.005	-23.25	44.14	150.37	-302.13	-0.04	2.02
	(0.72)	(1.44)	(1.45)	(1.50)	(1.49)	(0.21)	
Japan	-0.022	9.46	-1.28	-30.70	3.61	0.49	1.72
	(1.41)	(1.27)	(0.10)	(1.09)	(0.13)	(0.69)	
Netherlands	-0.002	-10.94	6.37	82.48	-26.27	0.33	1.88
	(0.16)	(0.24)	(0.12)	(0.26)	(0.09)	(0.45)	
New Zealand	-0.008	110.45	163.27	-625.69	-945.07		2.04
	(0.30)	(0.23)	(0.35)	(0.24)	(0.36)		
Norway	0.014	30.09	22.01	-223.08	-128.75	0.36	2.10
	(0.77)	(0.89)	(1.36)	(1.05)	(1.34)	(2.36)	
Spain	0.025	-14.08*	16.64	40.39	-59.76	-0.43	2.05
	(1.41)	(1.94)	(1.60)	(1.30)	(1.59)	(2.38)	
Sweden	-0.010	-26.70*	12.23	200.34	-93.64	0.05	1.99
	(1.21)	(1.82)	(1.59)	(1.63)	(1.53)	(0.40)	
United Kingdom	0.012	22.78	65.25***	-171.75	-359.00**	0.20	1.99
	(1.49)	(0.67)	(2.72)	(0.81)	(2.39)	(1.25)	
United States	-0.011	-16.42*	-10.26**	92.54*	50.56**	0.70	1.77
	(2.02)	(1.98)	(2.29)	(1.96)	(2.09)	(7.73)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta PIp-\Delta GDPp$ is the change in the log of the private investment deflator index minus the change in the log of the GDP deflator index. PI is private investment, PK is the private capital stock, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, IMF, own calculations and estimations*

Table 4.22: Construction Investment Deflator/GDP Deflator (OLS)

	c	$\Delta(CONi_t)$	$((CONi_t)^2-(CONi_{t-1})^2)$	AR(1)	$RBAR^2$	DW
Austria	0.002	-0.14	0.02	-0.41	0.12	1.97
	(0.67)	(0.57)	(0.35)	(2.18)		
Belgium	0.002	-2.98	0.47	0.27	0.26	2.17
	(0.31)	(1.00)	(0.94)	(1.80)		
Canada	-0.001	-0.14	0.03	0.32	0.23	1.83
	(0.24)	(0.36)	(0.66)	(2.46)		
Denmark	0.000	1.08	-0.12		0.17	2.01
	(0.05)	(1.20)	(1.29)			
Finland	0.001	-1.37	0.32*		0.30	1.92
	(0.23)	(1.55)	(1.75)			
France	0.002	-7.54*	0.79*	0.31	0.08	2.00
	(0.93)	(1.76)	(1.77)	(2.40)		
Germany	0.002	0.80**	-0.06**	0.37	0.28	1.77
	(0.46)	(2.53)	(2.53)	(2.96)		
Greece	0.012	-0.11	0.01	0.13	-0.04	2.01
	(1.41)	(0.26)	(0.09)	(0.59)		
Ireland	0.008	-1.21***	0.33***		0.20	2.07
	(1.25)	(3.14)	(4.16)			
Italy	0.004	-9.75	1.07	0.47	0.14	1.85
	(0.56)	(1.61)	(1.63)	(4.61)		
Japan	0.005	-7.10**	0.32**	0.30	0.05	1.75
	(1.29)	(2.16)	(2.22)	(1.71)		
Netherlands	0.008	1.57	-0.21	0.42	0.13	1.83
	(2.36)	(0.78)	(0.77)	(2.52)		
Norway	-0.001	-1.88**	0.21**		0.19	1.83
	(0.22)	(2.14)	(2.26)			
Spain	0.001	-1.58***	0.21***	0.32	0.14	1.89
	(0.33)	(3.02)	(3.20)	(2.45)		
Sweden	0.002	2.69	-0.26	0.24	0.10	2.02
	(0.43)	(0.73)	(0.69)	(1.65)		
United Kingdom	0.007	-0.39*	0.00	0.33	0.12	1.87
	(0.66)	(1.82)	(0.13)	(2.40)		
United States	0.010	-0.68***	0.05***	0.55	0.34	1.75
	(2.38)	(3.28)	(3.13)	(3.68)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔCONp-ΔGDPp is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: ΔCONi is the change in the log of real construction investment and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.23: Construction Investment Deflator/GDP Deflator (TSLS)

	c	$\Delta(CONi_t)$	$((CONi_t)^2-(CONi_{t-1})^2)$	AR(1)	DW
Austria	0.001	-0.17	0.03	-0.41	1.96
	(0.19)	(0.32)	(0.34)	(2.12)	
Belgium	0.002	-4.27	0.69	0.29	2.15
	(0.28)	(0.58)	(0.55)	(1.46)	
Canada	0.000	3.56	-0.40	0.44	1.78
	(0.01)	(1.01)	(1.02)	(3.42)	
Denmark	0.000	5.20	-0.57		2.01
	(0.02)	(1.32)	(1.35)		
Finland	0.004	-5.33	1.15		1.94
	(0.49)	(1.34)	(1.48)		
France	0.004	-124.52	13.01	0.24	1.82
	(0.73)	(0.85)	(0.85)	(1.71)	
Germany	-0.001	-2.08	0.24	0.04	1.99
	(0.30)	(0.74)	(0.86)	(0.62)	
Greece	0.020	-3.37	0.61	0.07	1.81
	(1.63)	(1.39)	(1.37)	(0.48)	
Ireland	0.005	-0.45	0.17**	-0.16	2.06
	(0.77)	(1.18)	(2.25)	(1.19)	
Italy	0.005	-51.32	5.55	0.33	1.74
	(0.55)	(0.83)	(0.83)	(1.23)	
Japan	0.007	-2.77	0.39	0.38	2.20
	(0.46)	(1.16)	(1.16)	(3.07)	
Netherlands	0.007	-53.09	2.44	0.51	1.83
	(2.07)	(0.39)	(0.40)	(2.56)	
Norway	-0.001	-4.10	0.45	0.08	1.99
	(0.24)	(1.54)	(1.58)	(0.57)	
Spain	-0.001	-1.093	0.16	0.34	1.91
	(0.34)	(0.83)	(1.01)	(2.39)	
Sweden	0.008	63.86	-6.15		1.85
	(0.56)	(1.05)	(1.05)		
United Kingdom	-0.012	0.67	0.04	0.14	1.95
	(0.63)	(0.67)	(0.59)	(0.53)	
United States	0.016	-16.77	1.32	0.14	1.10
	(1.60)	(1.17)	(1.16)	(1.66)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta GDPp$ is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.24: Construction Investment Deflator/GDP Deflator with Asymmetry (OLS)

	c	$(\Delta CONi)\gamma 1$	$(\Delta CONi)\gamma 2$	$((CONi_t)^2-(CONi_{t-1})^2)\gamma 1$	$((CONi_t)^2-(CONi_{t-1})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Austria	0.004	-0.10	-1.05	0.00	0.18	-0.41	0.08	1.98
	(0.55)	(0.37)	(0.51)	(0.04)	(0.56)	(2.09)		
Belgium	0.008	-3.19	-1.49	0.49	0.23	0.27	0.24	2.14
	(1.01)	(0.99)	(0.28)	(0.92)	(0.26)	(1.71)		
Canada	0.001	0.14	-4.94	-0.01	0.56	0.34	0.21	1.80
	(0.28)	(0.29)	(1.58)	(0.11)	(1.66)	(2.69)		
Denmark	0.001	0.32	1.38	-0.05	-0.16		0.14	2.01
	(0.58)	(0.31)	(0.94)	(0.41)	(0.98)			
Finland	-0.001	-0.21	-5.33***	0.08	1.10***		0.46	2.15
	(0.15)	(0.45)	(5.08)	(0.91)	(5.09)			
France	0.003	-13.49**	7.71	1.41**	-0.80	0.21	0.11	2.00
	(1.41)	(2.09)	(0.86)	(2.09)	(0.85)	(1.67)		
Germany	0.004	0.57	4.06	-0.04*	-0.37	0.42	0.27	1.72
	(0.62)	(1.46)	(1.31)	(1.78)	(1.20)	(2.59)		
Greece	0.000	-0.67	0.82	0.15	-0.17		0.04	1.85
	(0.06)	(1.13)	(0.80)	(1.28)	(0.95)			
Ireland	-0.003	-0.75***	-9.72**	0.25***	2.52**	-0.19	0.40	2.04
	(0.69)	(3.13)	(2.61)	(4.48)	(2.65)	(0.92)		
Italy	0.004	-11.11	-7.95	1.22	0.87	0.47	0.07	1.86
	(0.54)	(0.78)	(1.25)	(0.79)	(1.27)	(4.16)		
Japan	-0.001	-6.22*	-12.29*	0.29*	0.55*	0.20	0.05	1.85
	(0.22)	(1.79)	(1.95)	(1.88)	(1.94)	(1.40)		
Netherlands	0.003	-4.74**	7.37	0.67**	-1.03*	0.42	0.28	1.81
	(0.72)	(2.64)	(1.66)	(2.67)	(1.69)	(1.91)		
Norway	0.003	-1.42	-2.69	0.16*	0.31		0.18	1.89
	(0.97)	(1.63)	(0.48)	(1.68)	(0.54)			
Spain	0.007	-1.88***	0.72	0.23***	-0.05	0.41	0.14	1.83
	(1.01)	(3.39)	(0.34)	(3.29)	(0.20)	(3.14)		
Sweden	-0.002	3.70	3.58	-0.33	-0.35	0.23	0.09	1.99
	(0.46)	(0.65)	(0.76)	(0.58)	(0.75)	(1.77)		
United Kingdom	0.017	-3.65	-0.03	0.38	-0.01	-0.33	0.12	1.91
	(1.33)	(1.27)	(0.15)	(1.03)	(0.55)	(2.74)		
United States	0.012	-0.67***	-2.56	0.04***	0.20	0.54	0.31	1.80
	(2.97)	(3.27)	(0.77)	(3.48)	(0.75)	(3.52)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta GDPp$ is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment. $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive. $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.25: Construction Investment Deflator/GDP Deflator with Asymmetry (TSLS)

	c	$(\Delta CONi)\gamma 1$	$(\Delta CONi)\gamma 2$	$((CONi_t)^2-(CONi_{t-1})^2)\gamma 1$	$((CONi_t)^2-(CONi_{t-1})^2)\gamma 2$	AR(1)	DW
Austria	0.006	-0.02	0.76	-0.01	-0.08	-0.40	1.99
	(0.62)	(0.03)	(0.17)	(0.13)	(0.11)	(2.21)	
Belgium	0.004	7.89	-2.14	-1.44	0.33	0.12	2.06
	(0.42)	(1.18)	(0.40)	(1.24)	(0.36)	(0.63)	
Canada	-0.041	0.76	-4.63	0.03	0.44	-0.12	2.09
	(1.19)	(0.48)	(0.11)	(0.17)	(0.10)		
Denmark	0.006	5.83	4.43	-0.65	-0.48	-0.09	2.04
	(0.78)	(1.32)	(1.49)	(1.37)	(1.46)	(0.55)	
Finland	-0.042	1.93	-5.67***	-0.18	1.11**	0.11	2.00
	(0.89)	(0.82)	(2.74)	(0.37)	(2.62)	(0.71)	
France	-0.002	-16.06	32.70**	1.69	-3.45*	0.05	1.99
	(0.24)	(1.52)	(2.03)	(1.55)	(2.01)	(0.15)	
Germany	-0.033	1.47	1.69	-0.02	-0.21	-0.09	2.02
	(1.58)	(0.67)	(0.44)	(0.13)	(0.57)	(0.53)	
Greece	0.027	-0.71	1.08	0.08	-0.21	0.22	2.02
	(1.15)	(0.46)	(0.20)	(0.27)	(0.21)	(1.55)	
Ireland	-0.020	-0.64	-4.17	0.28**	0.83	0.04	2.03
	(1.22)	(1.39)	(0.52)	(2.65)	(0.36)	(0.56)	
Italy	-0.015	-31.96	47.39	3.57	-5.27	0.48	2.04
	(0.90)	(1.17)	(0.86)	(1.20)	(0.86)	(3.93)	
Japan	-0.025	-11.40	1.20	0.55	-0.10	0.21	2.05
	(1.71)	(1.06)	(0.03)	(1.11)	(0.07)	(1.24)	
Netherlands	0.003	-3.62	14.28**	0.51	1.97**	0.51	1.83
	(0.72)	(0.77)	(2.48)	(0.78)	(2.46)	(2.71)	
Norway	0.002	-2.16	-1.58	0.25	0.22	0.06	1.99
	(0.26)	(0.56)	(0.09)	(0.60)	(0.12)	(0.46)	
Spain	0.003	-1.02	6.48	0.15	-0.76	0.44	1.95
	(0.24)	(0.68)	(0.65)	(0.78)	(0.60)	(2.15)	
Sweden	-0.008	11.08	10.71*	-1.00	-1.04*	0.11	1.96
	(0.64)	(1.15)	(1.91)	(1.05)	(1.87)	(0.70)	
United Kingdom	0.060	-5.14	3.20	0.43	-0.48	0.52	1.59
	(1.85)	(0.38)	(0.64)	(0.25)	(0.70)	(4.26)	
United States	0.025	-2.88	15.17	0.19	-1.17	0.47	1.81
	(2.26)	(1.12)	(0.82)	(1.00)	(0.82)	(2.91)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta GDPp$ is the change in the log of the construction investment deflator index minus the change in the log of the GDP deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.26: Equipment Investment Deflator/GDP Deflator (OLS)

	c	$\Delta(EQi_t)$	$((EQi_t)^2-(EQi_{t-1})^2)$	AR(1)	$RBAR^2$	DW
Austria	-0.014	0.35	-0.06	0.12	0.02	1.92
	(2.78)	(1.39)	(1.27)	(1.23)		
Belgium	0.011	-3.72*	0.52	0.36	0.84	1.99
	(1.01)	(1.95)	(1.46)	(2.40)		
Canada	-0.018	0.31	-0.08	0.42	0.26	1.80
	(2.92)	(0.97)	(1.43)	(3.49)		
Denmark	-0.022	-0.48	0.06	0.29	0.03	1.87
	(2.38)	(1.33)	(1.23)	(1.97)		
Finland	-0.010	-0.17	0.03	0.35	0.10	1.99
	(1.48)	(1.23)	(0.74)	(1.78)		
France	-0.016	0.35	-0.08	-0.13	0.07	1.96
	(2.30)	(0.58)	(0.84)	(0.54)		
Germany	-0.010	0.12	-0.01	0.45	0.15	1.94
	(2.04)	(1.39)	(2.03)	(2.68)		
Greece	-0.004	-0.11	-0.02	0.24	0.08	1.90
	(0.40)	(1.59)	(0.76)	(1.76)		
Ireland	-0.010	-0.50***	0.16***	0.55	0.23	2.02
	(0.95)	(3.16)	(2.85)	(4.63)		
Italy	-0.013	1.25	-0.14	0.34	0.04	1.83
	(1.99)	(0.97)	(0.97)	(1.94)		
Japan	-0.014	-2.26***	0.10***	0.37	0.35	2.05
	(5.06)	(4.43)	(4.25)	(2.68)		
Netherlands	-0.014	-0.17	0.02	0.66	0.40	2.10
	(1.62)	(0.58)	(0.30)	(3.39)		
Norway	0.006	1.37*	-0.21***	0.61	0.73	1.63
	(0.29)	(1.98)	(2.84)	(6.84)		
Spain	-0.015	-0.017	0.00	0.29	0.01	2.05
	(2.88)	(0.05)	(0.08)	(2.05)		
Sweden	-0.018	-1.02	0.11	0.31	0.04	1.91
	(2.20)	(1.35)	(1.24)	(2.34)		
United Kingdom	-0.005	2.70**	0.40**	0.26	0.31	2.07
	(0.41)	(2.32)	(2.49)	(1.40)		
United States	-0.014	-0.42	0.03	0.78	0.60	2.14
	(1.40)	(1.43)	(0.95)	(11.05)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta EQp-\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: ΔEQi is the change in the log of real equipment investment and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.27: Equipment Investment Deflator/GDP Deflator (TSLS)

	c	$\Delta(EQi_t)$	$((EQi_t)^2-(EQi_{t-1})^2)$	AR(1)	DW
Austria	-0.008	-0.62	0.12		1.97
	(3.58)	(0.86)	(0.90)		
Belgium	0.003	-5.72**	0.95**	-0.12	2.00
	(0.36)	(2.36)	(2.32)	(0.67)	
Canada	-0.027	0.53*	-0.09*	0.37	1.78
	(2.28)	(1.81)	(1.94)	(2.89)	
Denmark	-0.040	6.41*	-0.78*		1.87
	(1.94)	(1.73)	(1.75)		
Finland	-0.015	1.96	-0.55	-0.04	1.94
	(1.90)	(1.39)	(1.40)	(0.33)	
France	-0.026	3.20	-0.42	0.02	2.01
	(1.96)	(1.35)	(1.48)	(0.06)	
Germany	-0.010	-0.54	0.05	0.23	2.04
	(1.47)	(1.09)	(1.11)	(1.09)	
Greece	-0.014	0.10	-0.05	0.08	1.96
	(0.88)	(0.56)	(1.50)	(0.59)	
Ireland	-0.015	0.38	-0.13	-0.07	2.00
	(2.10)	(1.57)	(1.46)	(0.44)	
Italy	-0.012	0.30	-0.03	0.30	1.88
	(1.89)	(0.17)	(1.65)	(1.41)	
Japan	-0.025	-10.22	0.51	0.40	1.60
	(1.98)	(1.02)	(1.01)	(2.46)	
Netherlands	-0.015	-1.06	0.19	0.66	2.17
	(1.55)	(1.14)	(1.03)	(3.12)	
Norway	0.006	1.69	-0.25**	0.60	1.65
	(0.29)	(1.52)	(2.13)	(6.51)	
Spain	-0.012	0.77	-0.13	0.38	1.98
	(2.19)	(0.67)	(0.73)	(1.75)	
Sweden	-0.022	8.27	-0.89		1.97
	(1.86)	(1.11)	(1.10)		
United Kingdom	-0.003	19.77	-2.61	0.20	1.87
	(0.23)	(0.70)	(0.71)	(2.21)	
United States	-0.013	1.11***	-0.11***	0.36	1.84
	(1.44)	(2.76)	(3.10)	(4.47)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta EQp-\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: ΔEQi is the change in the log of real equipment investment and AR(1) is the first order autoregressive coefficient.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.28: Equipment Investment Deflator/GDP Deflator with Asymmetry (OLS)

	c	$(\Delta EQi)\gamma 1$	$(\Delta EQi)\gamma 2$	$((EQi_t)^2-(EQi_{t-1})^2)\gamma 1$	$((EQi_t)^2-(EQi_{t-1})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Austria	-0.010	0.14	1.17	-0.02	-0.21		0.02	1.84
	(3.24)	(0.64)	(1.21)	(0.59)	(1.20)			
Belgium	-0.009	-1.84	-9.56***	0.26	1.57***	0.53	0.90	2.07
	(1.10)	(1.07)	(5.41)	(0.83)	(4.81)	(2.52)		
Canada	-0.019	0.26	0.98**	-0.07	-0.18**	0.43	0.22	1.81
	(1.82)	(0.72)	(2.21)	(1.09)	(2.36)	(3.37)		
Denmark	-0.009	-0.24	-3.25	0.01	0.50*	0.12	0.05	1.92
	(0.78)	(0.49)	(1.60)	(0.13)	(1.75)	(0.98)		
Finland	-0.006	-0.15	-0.19	0.01	0.04	0.38	0.06	2.00
	(0.64)	(0.60)	(0.74)	(0.09)	(0.71)	(2.05)		
France	-0.005	0.48	-4.08***	-0.12*	0.60***	-0.36	0.26	1.86
	(0.97)	(1.18)	(4.43)	(1.82)	(4.56)	(1.31)		
Germany	-0.015	-0.83	0.04	0.10	-0.01	0.58	0.19	2.07
	(2.13)	(1.59)	(0.31)	(1.57)	(1.56)	(4.08)		
Greece	-0.002	-0.13	0.25	-0.02	-0.16	0.24	0.03	1.90
	(0.09)	(1.02)	(0.12)	(0.70)	(0.17)	(1.72)		
Ireland	-0.013	-0.25***	-1.03**	0.07	0.35*	0.45	0.27	1.91
	(1.32)	(2.76)	(1.93)	(1.66)	(1.78)	(3.15)		
Italy	-0.012	-0.26	3.76**	0.03	-0.43**	0.50	0.02	1.69
	(1.05)	(0.14)	(2.37)	(0.16)	(2.35)	(3.03)		
Japan	-0.019	-1.30	-4.29***	0.06	0.20***	0.59	0.35	2.20
	(3.09)	(1.31)	(5.46)	(1.26)	(5.29)	(4.47)		
Netherlands	-0.016	-0.30	0.17	0.04	-0.06	0.68	0.38	2.13
	(1.32)	(0.60)	(0.22)	(0.50)	(0.41)	(3.50)		
Norway	-0.009	1.03	1.56	-0.15*	-0.25	0.59	0.74	1.62
	(0.51)	(1.54)	(0.91)	(1.93)	(1.31)	(5.07)		
Spain	-0.014	-0.43*	2.19*	0.07	-0.33*	0.36	0.04	2.01
	(1.76)	(1.73)	(1.68)	(1.54)	(1.69)	(2.06)		
Sweden	-0.006	-0.10	-3.74***	-0.01	0.44***	0.10	0.14	1.88
	(0.70)	(0.16)	(4.14)	(0.14)	(4.15)	(1.16)		
United Kingdom	-0.020	-0.46	9.35***	0.04	-1.31***	0.63	0.49	1.74
	(1.16)	(0.47)	(4.22)	(0.28)	(4.28)	(4.25)		
United States	-0.017	0.21	-1.93*	-0.03	0.15	0.59	0.70	1.58
	(3.56)	(1.07)	(1.92)	(1.35)	(1.62)	(6.27)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta EQp-\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: ΔEQi is the change in the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.29: Equipment Investment Deflator/GDP Deflator with Asymmetry (TSLS)

	c	$(\Delta EQi)\gamma 1$	$(\Delta EQi)\gamma 2$	$((EQi_t)^2-(EQi_{t-1})^2)\gamma 1$	$((EQi_t)^2-(EQi_{t-1})^2)\gamma 2$	AR(1)	DW
Austria	-0.014	0.17	7.05	-0.01	-1.42	0.05	1.98
	(0.77)	(0.36)	(1.34)	(0.15)	(1.28)	(0.77)	
Belgium	0.011	-6.42	-13.73	1.05	2.40		2.04
	(0.08)	(0.52)	(0.94)	(0.55)	(0.79)		
Canada	-0.053	0.61*	3.12	-0.06	-0.54	0.45	1.87
	(1.96)	(1.68)	(1.12)	(1.40)	(1.36)	(3.75)	
Denmark	-0.045	2.34	-14.44*	-0.29	1.74*	0.39	1.97
	(2.43)	(1.14)	(1.79)	(1.09)	(1.75)	(3.01)	
Finland	-0.056	0.92	-1.88	-0.12	0.42		2.14
	(1.15)	(0.68)	(0.36)	(0.26)	(0.31)		
France	-0.006	1.16**	-3.45	-0.20***	0.55*	-0.29	1.87
	(0.86)	(2.19)	(1.54)	(2.88)	(1.77)	(0.91)	
Germany	-0.011	-1.18	0.00	0.13	-0.01	0.59	2.11
	(0.97)	(1.20)	(0.01)	(1.06)	(0.33)	(3.74)	
Greece	0.004	-0.10	4.02	-0.06	-1.91	0.26	1.88
	(0.11)	(0.38)	(0.67)	(1.23)	(0.66)	(2.39)	
Ireland	-0.015	-0.14	-1.38*	0.04	0.49	0.37	1.88
	(1.13)	(0.69)	(1.88)	(0.75)	(1.57)	(2.26)	
Italy	-0.041	0.03	-7.67*	0.05	0.86	-0.16	1.99
	(2.75)	(0.02)	(1.73)	(0.27)	(1.69)	(1.42)	
Japan	-0.027	4.02	-9.71***	-0.19	0.45***	0.79	2.07
	(1.74)	(1.08)	(2.98)	(1.04)	(2.86)	(6.97)	
Netherlands	-0.029	-2.14	1.90	0.41	-0.42	0.79	2.36
	(1.52)	(1.33)	(0.80)	(1.35)	(0.96)	(6.79)	
Norway	0.035	2.74*	3.83	-0.38**	-0.45	0.53	1.90
	(1.26)	(1.87)	(0.68)	(2.06)	(0.75)	(3.29)	
Spain	-0.013	-0.229	-2.10	0.02	0.31	0.11	2.04
	(1.86)	(0.34)	(0.56)	(0.22)	(0.55)	(0.37)	
Sweden	-0.007	1.95	-2.13	-0.22	0.27	0.02	1.95
	(1.04)	(1.07)	(1.00)	(1.16)	(1.15)	(0.12)	
United Kingdom	0.058	-13.45	20.94	1.65	-2.38		1.82
	(0.64)	(0.28)	(0.32)	(0.27)	(0.28)		
United States	-0.053	0.10	-17.96	0.01	1.44		2.17
	(0.34)	(0.05)	(0.28)	(0.05)	(0.29)		

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta EQp-\Delta GDPp$ is the change in the log of the equipment investment deflator index minus the change in the log of the GDP deflator index. Independent variables: ΔEQi is the change in the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF*

Table 4.30: Government Investment Deflator/Private Investment Deflator (OLS)

	c	**1**	**2**	AR(1)	$RBAR^2$	DW
Australia	0.004	0.44	6.70	0.42	0.13	1.95
	(0.67)	(0.80)	(0.44)	(3.52)		
Austria	0.005	-1.86**	-18.57**		0.22	2.14
	(2.23)	(2.29)	(2.14)			
Belgium	-0.012	0.06	14.89***	0.70	0.50	2.09
	(0.75)	(0.16)	(2.84)	(6.85)		
Canada	-0.001	-0.33	-5.47	0.32	0.03	1.95
	(0.30)	(0.44)	(0.61)	(2.19)		
Denmark	0.012	-1.61	-41.49	-0.27	0.01	2.04
	(2.06)	(0.35)	(0.53)	(1.01)		
Finland	-0.006	-0.29	-0.25		0.01	1.92
	(1.56)	(0.75)	(0.06)			
France	0.006	0.45	23.17	0.42	0.11	2.01
	(1.43)	(0.36)	(0.63)	(1.89)		
Germany	-0.004	0.33	15.70*	0.49	0.17	1.75
	(0.79)	(0.93)	(1.78)	(3.73)		
Greece	-0.010	-0.68	2.44	-0.29	0.10	1.74
	(1.50)	(1.43)	(0.26)	(1.31)		
Ireland	0.013	0.91	10.08		0.02	1.97
	(3.31)	(0.83)	(0.47)			
Italy	0.003	-6.90***	-220.91***		0.71	2.08
	(0.72)	(3.92)	(2.75)			
Japan	0.010	0.08	1.95	0.20	-0.03	1.95
	(4.50)	(0.35)	(0.53)	(1.22)		
Netherlands	0.007	-0.58	7.31		0.05	1.72
	(3.07)	(1.12)	(0.32)			
New Zealand	0.001	0.27	4.84	0.34	0.04	1.79
	(0.18)	(1.01)	(0.93)	(1.94)		
Norway	-0.006	0.83	-19.37	0.22	0.03	1.85
	(1.46)	(1.22)	(1.30)	(1.70)		
Spain	0.011	-0.89	-9.79	-0.39	0.11	2.09
	(2.59)	(1.65)	(0.95)	(2.60)		
Sweden	-0.005	-1.66	46.86		0.22	1.70
	(1.28)	(1.27)	(1.39)			
United Kingdom	0.000	-3.17*	-83.80***		0.03	1.72
	(0.03)	(1.82)	(2.89)			
United States	0.005	-0.86	-14.89	0.57	0.31	2.26
	(0.93)	(1.24)	(1.08)	(4.06)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta GIp - \Delta PIp$ is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index, GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock and AR(1) is the first order autoregressive coefficient. **1** is $\Delta(GI_t/GK_{t-1}) - \Delta(PI_t/PK_{t-1})$. **2** is $((GI_t/GK_{t-1}) - (PI_t/PK_{t-1}))^2 - ((GI_{t-1}/GK_{t-2}) - (PI_{t-1}/PK_{t-2}))^2$, ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.31: Government Investment Deflator/Private Investment Deflator (TSLS)

	c	**1**	**2**	AR(1)	$RBAR^2$	DW
Australia	0.006	1.47*	-68.35	0.29	-0.82	1.86
	(0.87)	(1.77)	(1.50)	(2.63)		
Austria	0.01	-4.83	-60.02	-0.20	-0.38	2.01
	(1.68)	(1.67)	(1.32)	(0.99)		
Belgium	-0.009	1.81	-157.11*	0.28	-5.64	1.73
	(0.52)	(0.45)	(1.91)	(2.69)		
Canada	-0.002	-7.54	-166.31		-6.76	1.95
	(0.33)	(0.82)	(0.78)			
Denmark	0.009	-1.67	-26.44	-0.22	0.00	2.01
	(1.33)	(0.07)	(0.06)	(0.53)		
Finland	-0.003	-3.11**	56.98*	-0.15	-1.65	2.11
	(0.82)	(2.03)	(1.70)	(1.04)		
France	0.006	-1.92	-75.72	0.39	-0.02	1.91
	(1.58)	(0.73)	(0.99)	(1.94)		
Germany	-0.003	1.66	34.37**	0.55	-0.20	1.56
	(0.45)	(1.48)	(1.99)	(4.01)		
Greece	-0.013	0.25	56.38	-0.14	-0.19	1.98
	(1.74)	(0.17)	(1.25)	(0.78)		
Ireland	0.011	-1.17	-23.59	0.08	-0.27	1.99
	(2.60)	(0.56)	(0.57)	(0.43)		
Italy	0.003	-6.19	480.81	-0.25	-0.97	2.17
	(0.33)	(1.25)	(0.73)	(1.29)		
Japan	0.009	1.52	64.19		-3.67	1.87
	(2.90)	(0.58)	(0.57)			
Netherlands	0.008	-8.19	-267.12		-2.91	2.17
	(1.82)	(0.57)	(0.49)			
New Zealand	0.000	-0.13	4.95	0.30	0.04	1.87
	(0.05)	(0.43)	(0.20)	(0.83)		
Norway	-0.008	2.44	30.48	-0.12	-2.89	2.06
	(1.82)	(1.05)	(0.47)	(0.77)		
Spain	0.009	-5.20	-86.39	-0.22	-1.38	2.05
	(1.05)	(0.63)	(0.56)	(0.64)		
Sweden	-0.006	-1.86	52.75	0.13	0.21	1.94
	(1.28)	(1.18)	(1.19)	(1.05)		
United Kingdom	-0.002	18.26	343.13	0.14	-1.43	1.91
	(0.12)	(0.64)	(0.67)	(1.30)		
United States	0.005	-1.47	-50.98	0.59	-0.20	1.87
	(0.72)	(1.31)	(1.02)	(2.80)		

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta Glp - \Delta Plp$ is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index, GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock and AR(1) is the first order autoregressive coefficient. **1** is $\Delta(GI_t/GK_{t-1}) - \Delta(PI_t/PK_{t-1})$. **2** is $((GI_t/GK_{t-1}) - (PI_t/PK_{t-1}))^2 - ((GI_{t-1}/GK_{t-2}) - (PI_{t-1}/PK_{t-2}))^2$. The instrumental variables used are the trade-weighted averages of the relevant variables in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.32: Government Investment Deflator/Private Investment Deflator with Asymmetry (OLS)

	c	(**1**)γ1	(**1**)γ2	(**2**)γ1	(**2**)γ2	AR(1)	$RBAR^2$	DW
Australia	-0.004	2.16	-1.21	24.94	-9.16	0.40	0.17	1.96
	(0.46)	(1.33)	(1.66)	(0.59)	(0.53)	(3.57)		
Austria	0.001	-1.00	-2.92**	-12.18	-28.03*		0.22	2.06
	(0.27)	(1.39)	(2.14)	(1.59)	(1.85)			
Belgium	-0.007	-0.85	0.62	-3.58	-20.88**	0.75	0.49	2.02
	(0.33)	(1.23)	(1.27)	(0.32)	(2.21)	(6.86)		
Canada	0.003	-3.51***	1.57*	-37.91***	16.28	0.30	0.10	1.90
	(0.79)	(2.78)	(1.89)	(3.20)	(1.09)	(1.80)		
Denmark	0.017	3.28	-4.19*	50.12	-93.71***	-0.25	-0.01	2.05
	(1.56)	(0.39)	(1.98)	(0.32)	(3.35)	(1.06)		
Finland	-0.001	-0.39*	-0.08	-4.98	7.94		0.09	2.25
	(0.03)	(1.80)	(0.10)	(0.55)	(0.72)			
France	0.004	1.62	-0.53	54.37	6.29	0.44	0.07	1.99
	(0.78)	(1.27)	(0.22)	(1.21)	(0.11)	(2.14)		
Germany	-0.005	0.69*	0.28	-20.52	53.92***	0.52	0.25	1.76
	(0.85)	(1.84)	(0.31)	(1.50)	(3.07)	(5.31)		
Greece	-0.022	0.01	-2.46**	4.68	-4.11		-0.01	2.32
	(1.54)	(0.01)	(2.06)	(0.29)	(0.23)			
Ireland	0.006	1.30	0.47	0.71	21.90		0.05	1.90
	(1.09)	(0.72)	(0.39)	(0.02)	(0.82)			
Italy	-0.002	-5.66**	-7.73***	-223.40**	-213.22**		0.70	2.11
	(0.33)	(2.23)	(5.82)	(2.05)	(2.31)			
Japan	0.010	-0.03	0.17	1.22	0.86	0.21	-0.09	1.95
	(4.12)	(0.07)	(0.53)	(0.20)	(0.12)	(1.14)		
Netherlands	0.007	0.13	-1.51	32.73	-22.48		0.04	1.88
	(1.86)	(0.21)	(1.41)	(1.47)	(0.60)			
New Zealand	0.008	-0.27	0.80	10.67*	1.44	0.49	0.07	1.79
	(1.09)	(1.06)	(1.38)	(1.89)	(0.20)	(2.53)		
Norway	-0.014	2.71*	-1.49	-43.69*	10.86	0.21	0.07	1.76
	(2.06)	(1.97)	(1.10)	(1.88)	(0.40)	(2.07)		
Spain	0.016	-1.56**	-0.18	-21.23	0.57	-0.46	0.09	2.13
	(2.40)	(2.20)	(0.25)	(1.48)	(0.04)	(2.59)		
Sweden	0.003	-3.13*	0.71	85.56**	-10.84		0.41	1.70
	(0.61)	(1.95)	(1.17)	(2.09)	(1.09)			
United Kingdom	0.019	-6.61	-0.36	-81.37	-95.66***		0.03	1.78
	(0.80)	(1.62)	(0.11)	(1.55)	(5.41)			
United States	0.007	-3.22	0.88	-50.38	14.05	0.64	0.35	2.27
	(1.29)	(1.58)	(0.83)	(1.63)	(0.55)	(4.54)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: ΔGlp- ΔPlp is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index . GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, γ1 is a dummy variable which takes a value of 1 when the relevant variable is positive, γ2 is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. **1** is* $\Delta(GI_t/GK_{t-1}) - \Delta(PI_t/PK_{t-1})$. ***2** is* $(((GI_t/GK_{t-1})-(PI_t/PK_{t-1}))^2 - ((GI_{t-1}/GK_{t-2})-(PI_{t-1}/PK_{t-2}))^2)$, ***, ** and * *denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.33: Government Investment Deflator/Private Investment Deflator with Asymmetry (TSLS)

	c	(**1**)γ1	(**1**)γ2	(**2**)γ1	(**2**)γ2	AR(1)	DW
Australia	0.018	2.22	2.23	71.98	-111.18	0.28	1.97
	(1.03)	(0.82)	(0.92)	(1.30)	(1.44)	(1.46)	
Austria	0.002	-2.72*	-5.33*	-28.75	-68.33		2.21
	(0.19)	(1.87)	(1.73)	(1.25)	(1.74)		
Belgium	-0.036	-3.37	-3.12	-69.40	6.74	0.34	2.16
	(0.91)	(1.04)	(0.61)	(1.37)	(0.14)	(1.11)	
Canada	0.011	-19.92	-1.24	-304.17	-73.57		1.99
	(0.40)	(1.03)	(0.20)	(0.95)	(0.73)		
Denmark	0.016	-24.87	-6.84	-371.56	-156.88		2.07
	(0.53)	(0.44)	(0.35)	(0.46)	(0.36)		
Finland	0.007	-2.77	-1.03	26.07	27.35	-0.24	2.18
	(0.75)	(1.28)	(0.58)	(0.67)	(1.33)	(1.39)	
France	0.018	-8.38	1.99	-209.84	-95.97	0.21	1.96
	(1.17)	(1.28)	(0.34)	(1.21)	(0.91)	(1.25)	
Germany	-0.008	1.54	-0.30	8.55	75.86*	0.52	1.69
	(1.42)	(1.55)	(0.24)	(0.16)	(1.86)	(5.25)	
Greece	0.011	-3.82	2.50	23.91	61.54	-0.08	1.98
	(0.31)	(0.73)	(0.84)	(0.32)	(0.95)	(0.46)	
Ireland	-0.004	-0.47	-1.43	-41.05	19.98	0.06	1.97
	(0.50)	(0.22)	(0.53)	(0.70)	(0.44)	(0.45)	
Italy	0.001	-7.80*	-8.79***	-163.02	-182.92	0.07	1.95
	(0.11)	(1.83)	(12.12)	(1.28)	(0.75)	(0.40)	
Japan	0.015	2.75	3.10	131.87	87.84		2.13
	(0.42)	(0.28)	(0.27)	(0.32)	(0.42)		
Netherlands	-0.001	-0.31	-5.85***	-25.23	-85.14	-0.25	2.04
	(0.42)	(0.18)	(3.08)	(0.44)	(1.22)	(1.65)	
New Zealand	-0.001	-0.89	0.13	-23.04	6.60	0.21	1.83
	(0.11)	(0.71)	(0.14)	(0.92)	(0.42)	(1.26)	
Norway	-0.021	0.74	-6.74	14.92	93.14	0.36	2.12
	(2.16)	(0.42)	(1.59)	(0.29)	(1.09)	(2.43)	
Spain	0.028	-5.40**	-0.23	-78.47	-23.02	-0.42	2.00
	(1.88)	(2.17)	(0.17)	(1.72)	(1.10)	(2.79)	
Sweden	-0.005	-2.07	1.16	74.33	34.74	0.11	1.93
	(0.60)	(0.89)	(0.70)	(1.38)	(0.63)	(0.63)	
United Kingdom	0.089	-0.72	64.73	298.14	902.53	0.23	1.85
	(0.93)	(0.03)	(0.97)	(0.64)	(1.02)	(1.40)	
United States	-0.008	-3.74	-0.92	-70.38	68.13	0.47	1.94
	(0.63)	(0.86)	(0.26)	(1.00)	(1.11)	(2.05)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statisitics in parentheses. Δ is the first difference operator. Dependent variable: ΔGIp- ΔPIp is the change in the log of the government investment deflator index minus the change in the log of the private investment deflator index . GI is government investment, GK is the government capital stock, PI is private investment, PK is the private capital stock, γ1 is a dummy variable which takes a value of 1 when the relevant variable is positive, γ2 is a dummy variable which takes a value of 1 when the relevant variable is negative and AR(1) is the first order autoregressive coefficient. **1** is* $\Delta(GI_t/GK_{t-1}) - \Delta(PI_t/PK_{t-1})$. ***2** is* $(((GI_t/GK_{t-1}) - (PI_t/PK_{t-1}))^2 - ((GI_{t-1}/GK_{t-2}) - (PI_{t-1}/PK_{t-2}))^2)$, ****, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *OECD, own calculations and estimations*

Table 4.34: Construction Deflator/Equipment Deflator (OLS)

	c	$\Delta CONi-\Delta EQi$	$(CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2$	AR(1)	$RBAR^2$	DW
Austria	0.012	0.07	-0.10	-0.14	-0.03	1.95
	(3.38)	(0.36)	(0.57)	(0.60)		
Belgium	-0.002	-0.60**	-0.27	0.40	0.83	2.03
	(0.12)	(2.11)	(0.67)	(2.41)		
Canada	0.020	-0.27	-0.01	0.36	0.29	1.90
	(2.68)	(1.57)	(0.15)	(2.94)		
Denmark	0.019	0.18**	-0.19***	0.41	0.42	2.01
	(2.12)	(2.08)	(4.20)	(2.26)		
Finland	0.014	-0.35	0.16	0.43	0.19	1.72
	(1.41)	(1.31)	(0.98)	(2.83)		
France	0.016	-0.49	0.08		0.13	1.91
	(2.74)	(1.45)	(0.58)			
Germany	0.014	0.23	-0.18	0.41	0.14	1.96
	(2.12)	(1.24)	(1.13)	(3.75)		
Greece	0.017	0.02	-0.07	0.10	0.22	1.97
	(1.86)	(0.09)	(1.18)	(0.54)		
Ireland	0.03	0.45	-0.20	0.49	0.19	2.19
	(2.67)	(0.90)	(0.73)	(2.05)		
Italy	0.013	-0.04	0.04	0.45	0.13	2.21
	(2.00)	(0.59)	(0.59)	(2.47)		
Japan	0.019	-0.05	-0.12	0.47	0.20	2.03
	(2.68)	(0.24)	(0.83)	(3.41)		
Netherlands	0.027	0.09	-0.06	0.77	0.54	1.78
	(1.87)	(0.57)	(0.79)	(8.26)		
Norway	0.004	-0.58***	0.11**	0.34	0.73	1.85
	(0.33)	(22.49)	(2.04)	(3.07)		
Spain	0.019	0.22	-0.11	0.49	0.20	2.08
	(2.55)	(0.42)	(0.28)	(4.68)		
Sweden	0.021	0.08	-0.11**	0.60	0.25	1.78
	(1.74)	(0.85)	(2.17)	(4.01)		
United Kingdom	0.011	-0.98***	0.56	0.44	0.57	2.03
	(0.65)	(4.92)	(1.18)	(2.34)		
United States	0.023	-0.14	-0.03	0.66	0.46	2.09
	(1.92)	(0.72)	(0.48)	(5.03)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta EQp$ is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment and AR(1) is the first order autoregressive coefficient. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database.*

Table 4.35: Construction Deflator/Equipment Deflator (TSLS)

	c	ΔCONi-ΔEQi	$(CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2$	AR(1)	DW
Austria	0.125	0.02	0.04	-0.20	1.94
	(3.03)	(0.02)	(0.04)	(0.83)	
Belgium	0.004	-0.21	-0.09	-0.02	2.00
	(0.22)	(0.69)	(0.29)	(0.19)	
Canada	0.024	-0.23	0.03	0.38	1.82
	(2.66)	(0.99)	(0.38)	(3.18)	
Denmark	0.018	0.22	-0.24	0.41	2.07
	(1.83)	(0.97)	(1.46)	(2.13)	
Finland	-0.079	-77.77	50.56		1.82
	(0.03)	(0.04)	(0.04)		
France	0.021	-0.56	0.21		1.85
	(2.22)	(0.64)	(0.43)		
Germany	0.015	-0.74	0.59	0.44	1.68
	(1.57)	(0.41)	(0.35)	(1.25)	
Greece	-0.013	-0.54	-0.09		2.16
	(0.31)	(0.41)	(0.33)		
Ireland	0.031	1.39	-0.70	0.48	2.10
	(2.49)	(1.17)	(1.14)	(1.83)	
Italy	0.012	-0.01	-0.04	0.40	2.23
	(1.84)	(0.05)	(0.22)	(1.61)	
Japan	0.024	1.16	-1.00**	0.52	1.88
	(1.85)	(1.51)	(2.22)	(3.68)	
Netherlands	0.030	0.58	-0.28	0.75	1.96
	(2.09)	(1.02)	(1.05)	(6.80)	
Norway	0.004	-0.55***	-0.02	0.27	1.75
	(0.31)	(4.07)	(0.06)	(2.36)	
Spain	0.020	-3.33	2.06	0.58	1.80
	(1.38)	(1.16)	(1.17)	(7.80)	
Sweden	0.017	-0.12	-0.01	0.57	1.79
	(1.23)	(0.30)	(0.05)	(4.41)	
United Kingdom	0.010	-1.18***	0.69	0.46	1.96
	(0.56)	(5.39)	(1.45)	(2.44)	
United States	0.022	-0.16	-0.03	0.66	2.10
	(1.72)	(0.81)	(0.41)	(4.87)	

Notes: *Two-stage least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: ΔCONp- ΔEQp is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: ΔCONi is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment and AR(1) is the first order autoregressive coefficient. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, IMF, own calculations and estimations*

Table 4.36: Construction Deflator/Equipment Deflator with Asymmetry (OLS)

	c	$(\Delta CONi-\Delta EQi)\gamma 1$	$(\Delta CONi-\Delta EQi)\gamma 2$	$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 1$	$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 2$	AR(1)	$RBAR^2$	DW
Austria	0.01	0.10	0.01	0.00	-0.17	-0.17	-0.03	1.96
	(1.05)	(0.32)	(0.03)	(0.00)	(0.66)	(0.73)		
Belgium	0.007	-0.20	-0.48*	-1.09**	0.00	0.23	0.85	2.11
	(0.86)	(0.65)	(1.90)	(2.26)	(0.00)	(1.27)		
Canada	0.017	-0.47	-0.07	0.11	-0.11	0.43	0.28	1.94
	(1.46)	(1.66)	(0.20)	(1.12)	(0.86)	(2.87)		
Denmark	0.010	0.41***	0.13	-0.19***	-0.23**	0.45	0.45	2.10
	(0.85)	(2.85)	(0.81)	(3.43)	(2.26)	(2.57)		
Finland	-0.001	0.46	-0.84	-0.26	0.35	0.51	0.26	1.71
	(0.06)	(0.83)	(2.43)	(0.76)	(1.62)	(2.96)		
France	0.007	2.50***	-0.78**	-0.84***	0.14	-0.20	0.18	1.91
	(1.44)	(5.67)	(2.26)	(5.92)	(0.89)	(1.57)		
Germany	0.016	0.63***	0.08	-0.50***	-0.05	0.41	0.12	1.96
	(2.42)	(2.66)	(0.29)	(2.71)	(0.24)	(3.66)		
Greece	0.027	-0.55	0.10	0.05	-0.07		0.23	1.82
	(2.03)	(1.12)	(0.40)	(0.42)	(0.94)			
Ireland	0.031	1.333	-0.47	-0.73	0.32	0.46	0.19	2.08
	(2.83)	(1.35)	(0.64)	(1.23)	(0.79)	(1.93)		
Italy	0.009	-0.27	-0.05	0.69***	-0.10	0.67	0.36	1.80
	(0.96)	(0.93)	(0.52)	(3.32)	(1.24)	(9.17)		
Japan	0.016	-0.40	0.13	0.19	-0.29	0.44	0.20	2.02
	(2.03)	(1.17)	(0.36)	(1.07)	(1.11)	(2.89)		
Netherlands	0.026	-0.38	0.30	0.24	-0.20*	0.83	0.58	1.67
	(1.29)	(1.23)	(1.63)	(1.35)	(2.00)	(9.41)		
Norway	0.011	-0.59***	-0.59***	0.07	0.17***	0.34	0.72	1.88
	(0.97)	(11.85)	(4.71)	(0.70)	(2.74)	(2.76)		
Spain	0.020	0.77	-0.38	-0.50	0.33	0.50	0.17	2.07
	(2.31)	(1.11)	(0.69)	(0.99)	(0.87)	(5.17)		
Sweden	0.017	0.29	-0.02	-0.22**	-0.05	0.53	0.23	1.76
	(1.47)	(1.14)	(0.23)	(2.02)	(0.71)	(3.26)		
United Kingdom	0.027	-1.30***	-0.46	0.75**	-0.13	0.51	0.62	1.89
	(1.22)	(7.85)	(1.61)	(2.22)	(0.25)	(2.45)		
United States	0.013	0.47	-0.37**	-0.16	0.02	0.60	0.51	1.94
	(1.23)	(1.51)	(2.05)	(1.35)	(0.43)	(4.61)		

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta EQp$ is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative.***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database.*

Table 4.37: Construction Deflator/Equipment Deflator with Asymmetry (TSLS)

	c	$(\Delta CONi-\Delta EQi)\gamma 1$	$(\Delta CONi-\Delta EQi)\gamma 2$	$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 1$	$((CONi_t-EQi_t)^2-(CONi_{t-1}-EQi_{t-1})^2)\gamma 2$	AR(1)	DW
Austria	0.052	3.30	1.78	-3.83	-1.11		2.14
	(0.38)	(0.28)	(0.31)	(0.28)	(0.29)		
Belgium	-0.105	5.47**	-2.01*	-9.56**	0.64	0.54	2.15
	(1.49)	(2.27)	(1.88)	(2.39)	(0.65)	(5.83)	
Canada	0.033	-0.46*	0.10	0.06	-0.06	0.42	1.83
	(2.09)	(1.80)	(0.43)	(0.39)	(0.49)	(3.36)	
Denmark	0.010	1.01*	-0.42	-0.37*	0.11	0.15	1.93
	(0.67)	(1.86)	(1.32)	(1.82)	(0.65)	(0.48)	
Finland	-0.020	3.11*	-2.368	-2.00*	1.17	0.42	2.07
	(1.09)	(1.77)	(1.86)	(1.76)	(1.35)	(2.54)	
France	-0.005	5.69***	-1.55*	-1.55***	0.43	-0.20	1.96
	(0.96)	(3.47)	(1.94)	(2.98)	(1.11)	(1.34)	
Germany	0.028	-2.23	-0.63	1.47	0.68	0.46	1.59
	(1.71)	(0.67)	(0.81)	(0.69)	(0.99)	(3.15)	
Greece	0.129	41.45	1.30	-11.80	0.04		2.05
	(0.12)	(0.10)	(0.05)	(0.10)	(0.01)		
Ireland	-0.050	0.64	-5.32	0.72	2.31		2.13
	(0.76)	(0.11)	(1.19)	(0.20)	(1.16)		
Italy	0.013	0.46	0.24	-1.19	-0.35		2.04
	(1.24)	(0.83)	(0.95)	(0.75)	(1.25)		
Japan	0.001	0.63	0.03	0.26	-0.29	0.12	1.91
	(0.13)	(0.51)	(0.07)	(0.51)	(0.77)	(0.70)	
Netherlands	0.006	5.85	1.05	-2.21	-0.50		1.88
	(0.42)	(0.81)	(0.36)	(0.71)	(0.38)		
Norway	0.082	-1.25	-1.63	-0.04	1.14		2.08
	(0.89)	(1.49)	(1.06)	(0.07)	(1.03)		
Spain	0.014	0.12	-4.22	-0.14	2.70	0.55	1.96
	(0.66)	(0.04)	(1.38)	(0.06)	(1.58)	(4.39)	
Sweden	-0.027	1.60**	-0.62**	-0.20	0.06	0.03	1.98
	(1.10)	(2.36)	(1.89)	(0.38)	(0.45)	(0.21)	
United Kingdom	0.072	-5.03	-1.56	2.93	1.27		1.83
	(0.82)	(0.92)	(1.34)	(0.55)	(0.70)		
United States	0.015	0.76***	-0.60***	-0.38**	0.18**	0.35	1.88
	(1.42)	(2.74)	(3.39)	(2.51)	(2.67)	(2.42)	

Notes: *Least squares regression with Newey-West heteroscedasticity and autocorrelation consistent standard errors. t-statistics in parentheses. Δ is the first difference operator. Dependent variable: $\Delta CONp-\Delta EQp$ is the change in the log of the construction investment deflator index minus the change in the log of the equipment investment deflator index. Independent variables: $\Delta CONi$ is the change in the log of real construction investment, ΔEQi is the change in the log of real equipment investment, $\gamma 1$ is a dummy variable which takes a value of 1 when the relevant variable is positive, $\gamma 2$ is a dummy variable which takes a value of 1 when the relevant variable is negative. The instrumental variables used are the trade-weighted averages of the relevant variable in the particular country's trading partners. ***, ** and * denote significance at the 1, 5 and 10 per cent levels respectively.*

Source: *AMECO database, own calculations and estimations*

Chapter Five

Conclusion

The role of investment in the economy, both as a cyclical influence in the short-run and as a driver of long-term growth prospects, has been the subject of a substantial body of theoretical and empirical research. To economists, policymakers and the wider public, productive investment is seen as a deserving beneficiary of scarce resources. Rather less attention has been paid to factors that undermine its efficacy, a number of which are the subject of this thesis. Such considerations should clearly have a global resonance but are particularly important in an Irish context given the scale of the Government's fixed capital formation plans with an average 5.4% of Gross National Product committed to investment over the 2007 – 2013 period.

The first aim of our research is to consider the cyclicality of feasible discretionary spending by Irish governments over the 1960 to 2003 period. Government investment should be the most acyclical component of fiscal policy given that public investment projects are typically multi-year projects with long planning lead times and substantial completion lag times. Our analysis points to marked procyclicality in feasible discretionary government investment. Moreover, we show that not only is government feasible discretionary investment procyclical, it is deliberately procyclical. The evidence we present strongly supports the contention that when Irish policymakers have the resources, they spend them on feasible discretionary investment. As a consequence, we can conclude that government investment has been the residual in the Irish budgetary process over the 1969 to 2003 period.

This approach to the allocation of capital resources imposes clear short-term restraints on the effective management of the economic cycle and could, through a stop-start approach to government-funded capital formation, reduce the economy's sustainable growth potential. However, changes to Irish government capital allocation structures since 2003, the end of the period considered, should markedly reduce the procyclicality of investment going forward. These changes have included the introduction of rolling five-year multi-annual envelopes for all investment areas (other than the capital-intensive transport arena which now has a dedicated ten-year investment programme) and the promotion of greater flexibility in the allocation of capital resources between years. Taken with a strong political commitment to invest 5.4% of Gross National Product on average over the period 2007 to 2013, government investment should become increasingly and appropriately acyclical over the coming years.

We then explore the relation of public and private investment. We show that there is a long-term equilibrium relation between the public and private capital stocks in the great majority of developed countries considered. This chapter also presents solid empirical support for the hypothesis that any existing imbalance between private and public capital stocks is a driver of annual stock changes. Moreover, the output of our VECM analysis reveals that any imbalances in the relation of the public and private capital stocks of a country are more likely to be corrected through public-sector rather than private-sector adjustment. The chapter's estimated deviation findings allow us to conclude that capital imbalances are more likely to arise due to a relative deficiency in the public capital stock. Therefore, in the majority of countries, the adjustment to long-run equilibrium will involve positive public investment momentum and negative private investment momentum if the adjustment process is to be most expeditious or the former momentum only if that process is not to have a restraining effect on activity.

For the majority of countries considered, the relative size of the capital stocks makes it challenging for public investment to eliminate the imbalance in the absence of a sustained fall in private capital investment despite the presence of convergent momentum in public capital in each country. Given the long-term equilibrium relations presented here, we expect to see either a marked increase in government investment spending and/or a sustained decline in the private capital stock over the years ahead. There is limited evidence that public investment has a crowding-out impact on private investment with such an outturn highlighted in only four of our sample of twenty countries. Even in these cases, the increasing globalisation of capital flows should reduce the crowding-out impact. Rather than acting to impair private investment activity, we show that public investment is supportive of private investment and moves to correct any imbalance in their long-term relation.

Our final empirical chapter suggests that the neo-classical assumption that investment adjustment costs are convex has limited validity at the aggregate level. There is no evidence that aggregate investment costs accelerate as real investment expenditure growth becomes increasingly rapid in the OECD countries analysed as a unit. In fact, the analysis conducted shows that concavity at the total aggregate level arises during periods of disinvestment. We present similar results in relation to the private sector where investment costs decline at a diminishing rate during periods of investment contraction.

The results present no evidence in support of the view that there is a convex relation between cost and activity in government investment. In fact, the evidence presented in this chapter suggests that government investment costs are non-responsive to changes in government investment activity. On a relative basis, we present results suggesting that construction investment costs rise during construction investment expansions while equipment investment costs decline during equipment investment expansions.

From a policy perspective, there is a clear conclusion to be drawn. Concerns about the impact on price levels of an increase in investment activity should not be allowed to restrain investment where the deficit arises on foot of relatively insufficient government and equipment investment. It is only in relation to construction investment that caution should be exercised when planning large increases in activity due to evidence that there may be a positive relation between cost growth and activity levels as highlighted when they are considered relative to equipment investment.

There are possibilities for future research arising from this thesis. Extending the analysis of the impact of forecasts on discretionary investment to the wider OECD area may yield some interesting results. In addition, further work could be done on the causality of investment costs and activity in the construction and equipment sectors.

The findings of this thesis assuage concerns about the impact of the factors considered on the efficacy of investment. Our findings suggest that convexity arguments should not be used to defer investment, at least at the total aggregate level and that public investment performs a useful function in seeking to correct imbalances in the long-term relation between the government and private capital stocks. Concerns about the demonstrated pro-cyclicality of Irish government investment have diminished due to changes to capital allocation structures since 2003.

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