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# The Interaction of Public and Private Capital

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### The Interaction of Public and Private Capital

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3 **The Interaction of Public and Private Capital**  
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5 **A Study of 20 OECD Members\***  
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9 **Colin Hunt**  
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11 **Trinity College, Dublin**  
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13  
14 **August 2008**  
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20 **Abstract**  
21

22 This paper addresses the interaction of public and private capital stocks. We show for most  
23 developed countries that there is a long-term equilibrium relation between public and private  
24 capital. We find that imbalances in the relation of public and private capital are most likely to  
25 be corrected through a public capital adjustment. Private capital tends towards weak  
26 exogeneity. The evidence presented suggests that public investment is more likely to be enticed  
27 by private investment rather than serve to crowd out private investment activity.  
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57 their helpful comments.  
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## 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)).

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 paper adds to the existing body of work by estimating the cointegrating equations of public and private capital stock using Dynamic Ordinary Least Squares (DOLS) and by identifying which investment type is more likely to make necessary equilibrium-seeking adjustments.

This paper is organised as follows: Section 2 presents a short review of the literature; section 3 discusses data considerations; the methodology used in the paper is presented in section 4; our empirical results are outlined and discussed in section 5; while section 6 concludes.

## 2. Literature Review

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.

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3 Bosca, Cutanda and Escriba (2000) found that both public and private capital have followed  
4 criteria of efficient provision, characterised by an absence of systematic or significant  
5 differences in the rates of return to public and private capital in 17 OECD countries.  
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9 Voss (2002), in a study of the US and Canada, demonstrated that there is no evidence of  
10 crowding in due to complementarities between public and private investment with both  
11 countries experiencing a crowding out impact to private investment from public investment  
12 innovations.  
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17 Kamps (2005), in a comprehensive paper on the dynamic effects of public capital in the OECD,  
18 concluded that public and private capital are long-run complements for the vast majority of  
19 countries sampled while the short-run evidence is mixed<sup>1</sup>. Perotti (2004b) found that the short-  
20 term effect of government spending shocks and tax cuts on GDP have become substantially  
21 weaker over time and these effects, particularly on private investment, tend to be negative in  
22 the post-1980 period.  
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28 This paper is novel in demonstrating that momentum in public capital is more likely to respond  
29 to the existence of a capital stock imbalance and that public investment responds positively to  
30 innovations in private investment. In essence, our analysis suggests that public investment is  
31 less exogenous than private investment.  
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### 36 37 **3. Data**

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40 The sample period for this analysis is 1960 to 2003. Following Kamps (2004), we derive  
41 estimates of the public and private capital stocks in 20 OECD countries using the perpetual  
42 inventory method based on a geometric depreciation pattern. Real capital growth rates are  
43 sourced from the OECD database. In arriving at our estimates for capital stocks, we have  
44 assumed that public capital assets depreciate by 4% per annum, that non-residential private  
45 assets depreciate by 8% per annum, while residential private assets depreciate by 1.5% per  
46 annum. The private asset depreciation rate for each country is calculated by reference to the  
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54 <sup>1</sup> Kamps (2005) concentrates on the dynamic effects of public capital on employment, real GDP and  
55 private capital. The main findings are that shocks to public capital tend to have significant positive  
56 output effects, that there is little evidence for supernormal returns to public capital, that public and  
57 private capital are long-run complements in the majority of countries and that the long-run response of  
58 employment to a shock to public capital is statistically insignificant.  
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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:

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

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

$I_t$  is real gross investment in period  $t$

and  $\delta$  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 paper, 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”.

#### 4. Empirical Methodology

It is intuitively appealing to argue that the public and private capital stocks in a developed country should have some long-term equilibrium relation. While subject to some differing short-term factors, they should move in tandem over the longer-term in the absence of a fundamental shift in the economy's type. The existence of such an equilibrium 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:

$$GK_t = \theta PK_t^\beta \quad (2)$$

where  $PK$  is the private capital stock

and  $GK$  is the public capital stock

In logs, equation (2) becomes

$$gk_t = \alpha + \beta pk_t \quad (3)$$

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  $\beta$  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  $\beta$  is superconsistent, asymptotically normally distributed and efficient.

We estimate the cointegrating equation using DOLS (-2,2) as follows:

$$gk = \alpha + \beta pk + \gamma_1 \Delta pk_t + \gamma_2 \Delta pk_{t-1} + \gamma_3 \Delta pk_{t-2} + \gamma_4 \Delta pk_{t+1} + \gamma_5 \Delta pk_{t+2} + \varepsilon_t \quad (4)$$

Cointegration has implications for the short-term behaviour of the public and private capital stocks. If the variables are out of long-term equilibrium at a point in time, some mechanism must exist which pushes the variables to their equilibrium relation in the long term. 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 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 paper by a vector error-correction model as follows:

$$\begin{aligned}\Delta gk_t &= c - \delta_1(gk_{t-1} - \alpha - \beta pk_{t-1}) + \beta_1 \Delta gk_{t-1} + \beta_2 \Delta pk_{t-1} + \dots + \beta_i \Delta gk_{t-p} + \beta_j \Delta gk_{t-p} + \varepsilon_{1t} \\ \Delta pk_t &= c + \delta_2(gk_{t-1} - \alpha - \beta pk_{t-1}) + \gamma_1 \Delta gk_{t-1} + \gamma_2 \Delta pk_{t-1} + \dots + \gamma_i \Delta gk_{t-p} + \gamma_j \Delta pk_{t-p} + \varepsilon_{2t}\end{aligned}\tag{5}$$

where  $gk_t$  is the public capital stock

$pk_t$  is the private capital stock

$p$  is the number of lagged endogenous terms

and  $\varepsilon_t$  is a stochastic error term.

The Error-Correction Mechanism (ECM) coefficients given by  $\delta$  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  $\beta$  is positive, the ECM coefficient should be negatively signed if any short-run imbalances 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 imbalances are to be expedited. Of course, momentum in capital stocks which lead to the rapid elimination of any imbalances will be negative 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 at the country level, 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:

$$y_t = \alpha_1 y_{t-1} + \dots + \alpha_p y_{t-p} + \beta x_t + \varepsilon_t\tag{6}$$

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3 where  $y_t$  is a vector of endogenous variables  
4  $x_t$  is a vector of exogenous variable  
5  $\alpha_1, \dots, \alpha_p$  and  $\beta$  are matrices of coefficients to be estimated  
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7 and  $\varepsilon_t$  is a vector of innovations.  
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10 For the purposes of this paper, for those countries where VAR modeling is used, the real  
11 growth rates of private and public investment are the endogenous variables and no exogenous  
12 variables are included.  
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## 15 16 17 18 19 **5. Empirical Results**

### 20 21 22 **5.1 Testing for Cointegration**

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25 First, tests for the existence of a cointegrated relation between the private and public capital  
26 stocks were performed at the pool level. The results are reported in Table 1. We cannot reject  
27 the hypothesis that a unit root is present in the residuals of the long-term relation (equation 2) in  
28 our pooled regression for either version of the pooled cointegration test.  
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33 Having failed to prove the existence of a cointegrated relation at the pool level, tests for the  
34 presence of cointegration between the private and public capital stocks were conducted for each  
35 of the twenty countries under consideration. The full results of the Elliott-Rothenberg-Stock  
36 and Ng-Perron unit root tests are reported in Table 1a. The null hypothesis of no cointegration  
37 was rejected in the case of seventeen of the countries examined. In the cases of Finland,  
38 Greece and the United States, the null hypothesis could not be rejected at tolerable significance  
39 levels.  
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46 The results suggest, as expected, that there is a long-term equilibrium relation between the  
47 private and public capital stocks in the great majority of developed economies examined. As  
48 discussed earlier, this finding has important consequences for the modeling of the short-term  
49 dynamics of the private-public capital stock relation. For each of the seventeen countries where  
50 a cointegrating relation could not be rejected, we estimated a Vector Error Correction Model  
51 (VECM). Appropriate lag orders for the VAR and VECM analyses were chosen on the basis of  
52 a number of selection criteria. Those considered here include the Log Likelihood Ratio (LLR),  
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3 Final Precision Error information criterion (FPE), the Akaike information criterion (AIC), the  
4 Schwarz information criterion (BIC), and the Hannan and Quinn information criterion (HQ).  
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## 7 8 **5.2 Estimating Long-Run Relations**

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10 Table 2 presents the coefficients ( $\alpha$  and  $\beta$ ) which were estimated using a Dynamic OLS  
11 (DOLS) regression. DOLS allows for the long-run relation of the variables to be estimated  
12 even where the independent variables are not strictly exogenous. The use of DOLS generates  
13 strict exogeneity by including past and future changes in the independent variables. While the  
14 regressions were run primarily to generate estimated coefficients for the long-term relation that  
15 in turn would feed into the VECM analysis, the output can provide some insight into the long-  
16 run relation of the public and private capital stocks. In neoclassical growth theory, variables  
17 such as output and capital grow at the same constant rate in the steady state. However, our  
18 empirical evidence offers little support for the view that a unitary long-run relation exists  
19 between the public and private capital stocks with the estimated value of  $\beta$  being proximate to 1  
20 only in the case of Greece (1.04) and New Zealand (0.97). In eleven of the countries  
21 considered, the value of  $\beta$  was less than one with particularly small values being reported for  
22 the UK (0.33), Denmark (0.34), Ireland (0.55) and the Netherlands (0.59). In these countries,  
23 the private sector took a markedly more important role in capital formation relative to the  
24 public sector over the period under consideration. In nine countries, the value of  $\beta$  was greater  
25 than one with Finland (1.48), Belgium (1.41), Portugal (1.40) and Sweden (1.39) reporting the  
26 largest values. For completeness, the countries, including Finland, where the null hypothesis of  
27 no cointegration could not be rejected are included.  
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## 42 **5.3 Short-Run Dynamics**

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44 Taking account of the VECM output, summarized in Table 3, there is solid empirical support  
45 for the hypothesis that any disequilibrium between private and public capital stocks is a driver  
46 of annual capital stock changes. The error correction element of the VECM output is  
47 statistically significant at the 10% level in sixteen instances across the seventeen countries  
48 modeled using the VECM methodology. However, the ECM is considerably more likely to be  
49 statistically significant at the 10% level in the case of the public capital stock which accounts  
50 for eleven of the sixteen instances. Taking the first piece of substantive evidence, it appears  
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3 that the process of correcting imbalances in the relative capital stocks is more likely to be led  
4 by the public sector rather than the private sector.  
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8 As noted earlier when outlining the method employed in this analysis, the sign of the ECM  
9 coefficient should be negative where the change in the public capital stock is the dependent  
10 variable and/or positive where the change in the private capital stock is the dependent variable  
11 if imbalances are to be eliminated expeditiously. Further support for the view that the efficacy  
12 of the public sector in correcting imbalances is greater is provided by the VECM analysis in the  
13 context of the signs of the ECM coefficients. Where the public capital stock is the dependent  
14 variable, the ECM coefficient is negatively signed in every instance. As a consequence, we can  
15 conclude that the public capital stock responds in a gap-narrowing direction to imbalances in  
16 the relative capital stocks. The evidence where the change in the private capital stock is the  
17 dependent variable is rather mixed with a gap-narrowing positive sign being reported in nine  
18 cases while a negatively signed coefficient is reported in eight countries. However, it is only in  
19 two countries (Ireland and UK) that the ECM coefficient where the private sector is the left-  
20 hand variable is both negatively signed and statistically significant.  
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30 Given the relative statistical significance of the ECM coefficients and prevalence of gap-  
31 narrowing signs reported, the output of our VECM analysis leads us strongly to the view that  
32 any imbalances in the relation of the public and private capital stocks of a country are more  
33 likely to be corrected through public-sector rather than private-sector adjustment.  
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38 In the presence of cointegration, a variable is said to be weakly exogenous if it does not respond  
39 to the deviation from the long-term equilibrium relation. For the purposes of this paper, we  
40 take all instances where the error correction coefficient is statistically insignificant (at levels  
41 above 10%) or is zero as indicative of weak exogeneity (Enders (2004)). Given the relative  
42 statistical significance of the ECM coefficients discussed above, we can say that momentum in  
43 the private capital stock is more likely to tend towards weak exogeneity. Using the 10%  
44 threshold and allowing for countries slightly above it, the results summarized in Table 3 show  
45 that public investment is weakly exogenous in four cases (Austria, France, Japan and Norway)  
46 while private investment is weakly exogenous in twelve cases (Austria, Denmark, Canada,  
47 Australia, Germany, Norway, Sweden, New Zealand, Belgium, France, Italy and the  
48 Netherlands). The Japanese result is intuitive given the co-existence in that country of high  
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3 rates of government investment and depressed economic activity through the 1990s and early  
4 2000s.  
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8 Relative capital deficiencies can arise in one of two ways or indeed in a combination of both  
9 underinvestment in one stock type and overinvestment in another. A negative ECM coefficient  
10 where the change in the public capital stock is the left-hand variable and a positive ECM  
11 coefficient where the change in the private capital stock is the left-hand variable are two sides  
12 of the same coin in terms of accommodating an expeditious adjustment. The period of time  
13 needed to fully correct the disequilibrium is obviously hastened if both government and private  
14 capital are simultaneously adjusting in the appropriate direction. Indeed, our results suggest  
15 that such a two-handed approach to correcting the existence of a stock imbalance is somewhat  
16 short of universal with suitably-signed, countervailing ECM coefficients reported in the cases  
17 of nine of the seventeen countries considered. Countries experiencing double-edged  
18 convergence are Canada, Germany, Norway, Sweden, Japan, Portugal, France, Italy and Spain.  
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27 Moreover, in the case of all the other countries considered, with one notable exception, the  
28 inappropriately signed ECM coefficient where private investment is the left-handed variable is  
29 not of sufficient size to outweigh the public sector's imbalance-correcting adjustment although  
30 it does prolong the adjustment process.  
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35 The exception is Ireland where the imbalance-expanding ECM coefficient (where the change in  
36 the private capital stock is the left-hand variable (-0.124)) is larger than the imbalance-  
37 narrowing ECM coefficient (where the change in the public capital stock is the left-hand  
38 variable (-0.079)). Were overall capital momentum influenced solely by the presence of a  
39 relative imbalance in the long-term relationship and were such coefficients to exist indefinitely,  
40 Ireland would experience public sector investment growth attempting and failing to catch up  
41 with buoyant private capital formation. This finding runs counter to the results of the  
42 cointegration tests discussed earlier. As shown in Table 1, the evidence is strong that the capital  
43 stocks are cointegrated in the case of Ireland with the null hypothesis of no cointegration being  
44 rejected at the 1% level using both the Elliott-Rothenberg-Stock and Ng-Perron Unit Root  
45 Tests. This result for the period under study is not necessarily counter-intuitive given the pace  
46 of Irish economic growth since the early 1990s, the need for substantial growth by both public  
47 and private capital stocks to catch up with rapid growth in current activity, the role of private  
48 sector investment in that expansion, the emergence of boom-like conditions in real estate and a  
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2 relatively late response of government investment to private sector capital activity. However, it  
3 should be noted that our sample ends in 2003. Since then, the Irish Government has introduced  
4 multi-annual envelopes for all investment areas and in its latest National Development Plan has  
5 allocated more than 5% of GNP to Exchequer-funded capital investment over the period 2007-  
6 2013.  
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#### 10 11 12 **5.4 Impulse Response Functions** 13

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15 Impulse response functions were also calculated for each country. For the seventeen countries  
16 where the null hypothesis of no cointegration could not be rejected, the impulse response  
17 functions arising from the VECMs, the results of which are available upon request, were  
18 calculated and are presented graphically in the accompanying charts. For Finland, Greece and  
19 the USA, a series of simple impulse response functions were run with the lagged changes in the  
20 private and public capital stocks providing the endogenous variables. The variables were  
21 ordered so that the public capital stock was exogenous to the private capital stock.  
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28 The impulse response functions are presented graphically in Charts 1aa to 1tb. Each chart  
29 presents a point estimate of the impulse responses together with bootstrapped 90% confidence  
30 intervals on a 30 year horizon. The bootstrapping process employed took the following steps:  
31 First, the parameters of the model were estimated. Centred residuals were calculated using the  
32 estimated residuals. Then the bootstrap residuals were generated by randomly drawing with  
33 replacement from the set of centred residuals. These outputs were then used to construct the  
34 bootstrap time series recursively. The model was then re-estimated and the impulse response  
35 functions calculated. These steps were repeated 100 times to generate bootstrap distributions  
36 from which 90% confidence intervals were constructed.  
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45 The results of the impulse response functions present evidence on the relative responsiveness of  
46 public and private capital investment. In general, the response of public investment to an  
47 innovation in private investment is both positive and statistically significant with such outturns  
48 being reported, at least at some point in the response horizon, in sixteen of the twenty cases  
49 considered. In the remaining four cases, the responses are statistically insignificant by reference  
50 to the 90% confidence intervals.  
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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 paper that public investment responds more readily to private investment developments than vice versa.

## 6. Conclusions

The evidence presented in this paper 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 paper presents 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 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. 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.

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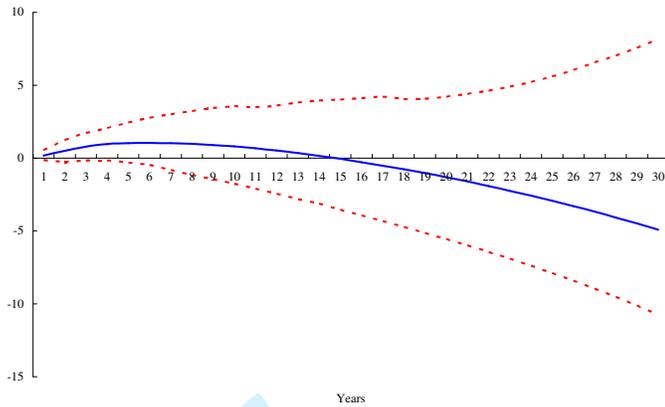
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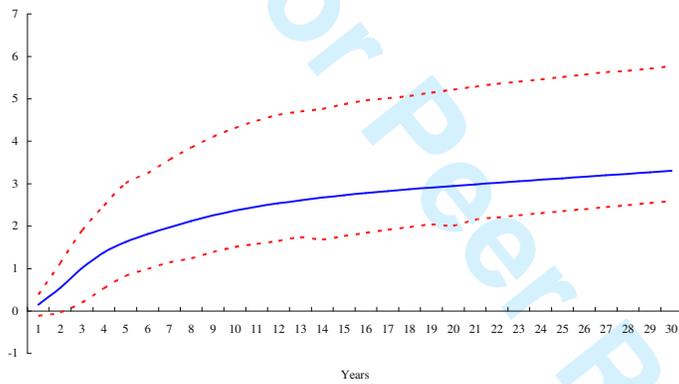
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**Chart 1.aa Austria - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



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



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

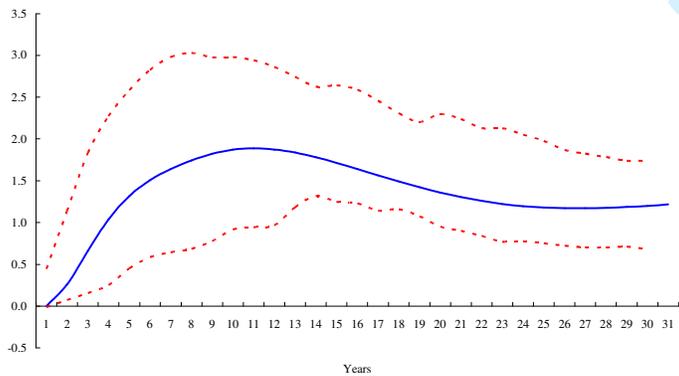


Chart 1.bb Australia - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

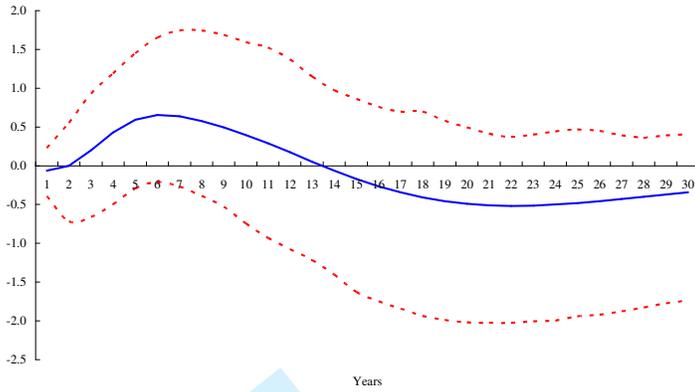


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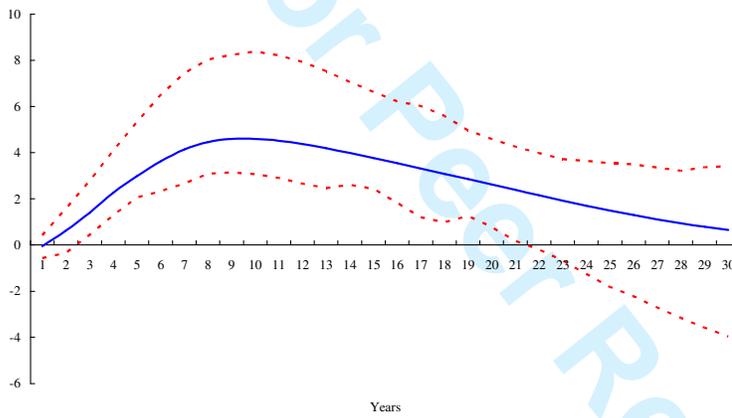
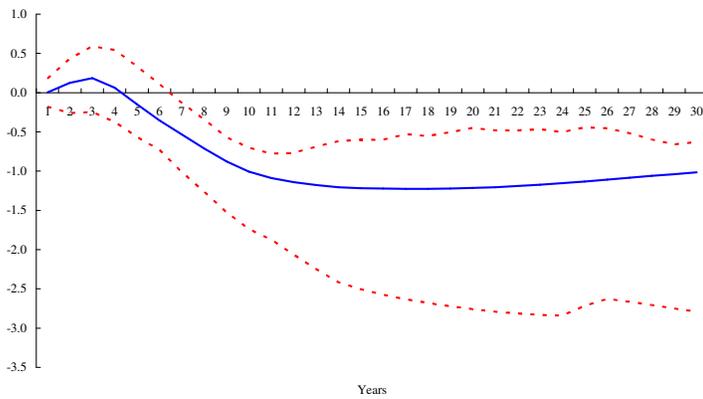
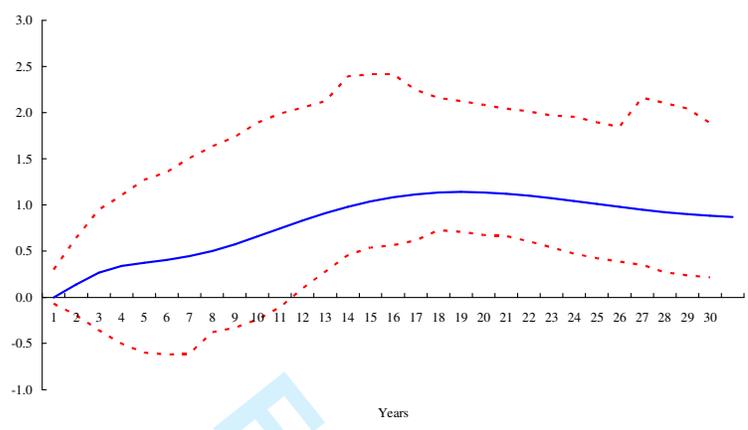


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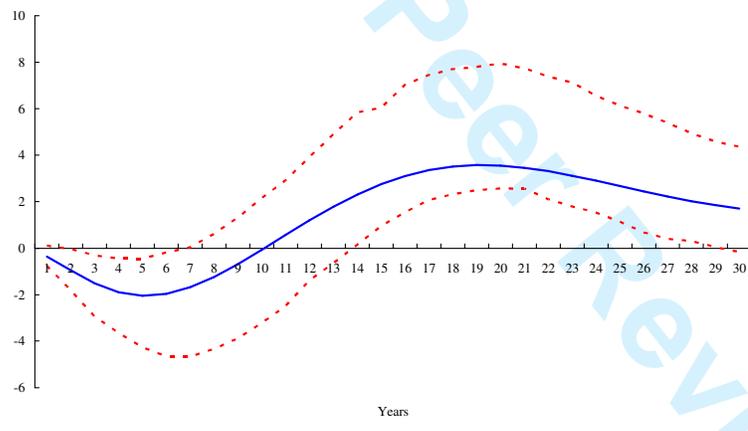


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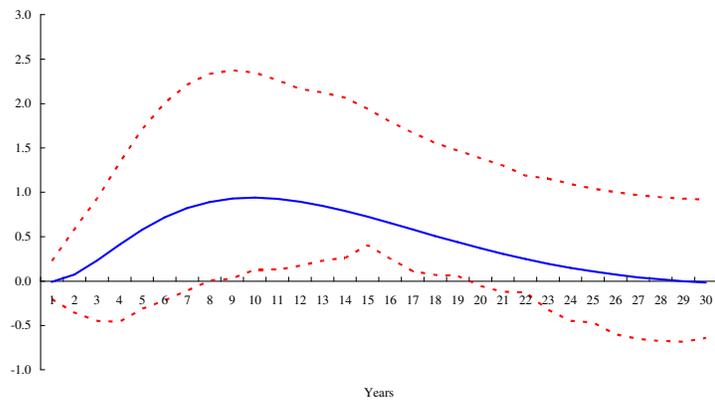
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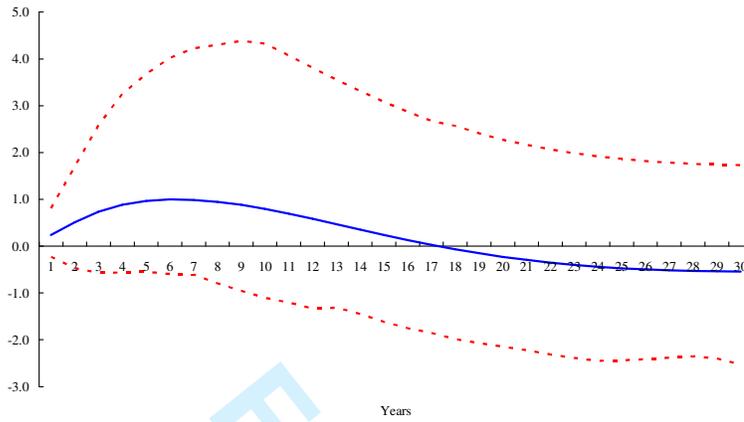
**Chart 1.db Canada - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment**



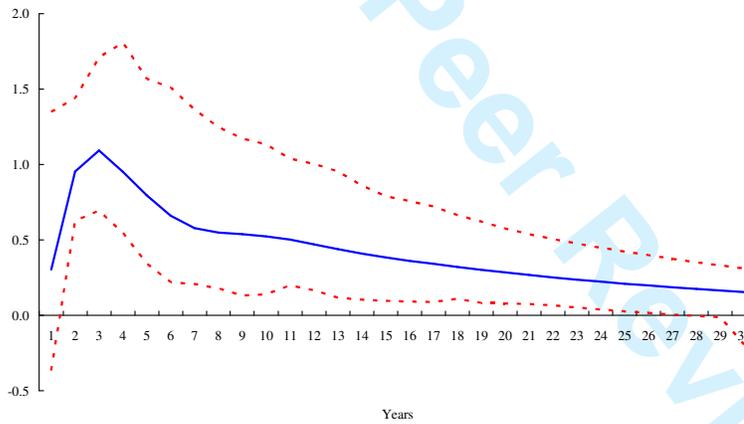
**Chart 1.ea Denmark - Impulse Reponse of Public Investment to a 1 S.D. Shock to Private Investment**



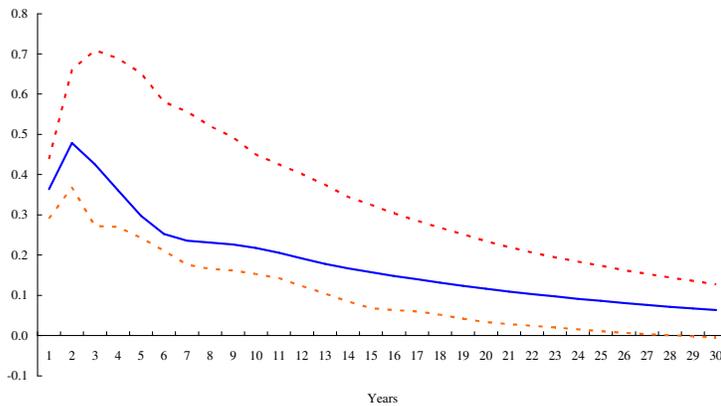
**Chart 1.eb Denmark - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment**



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

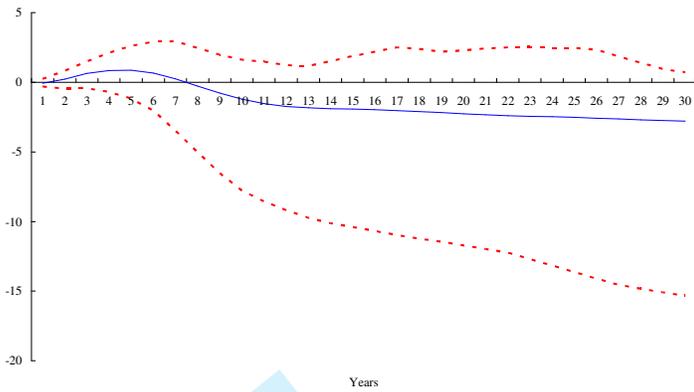


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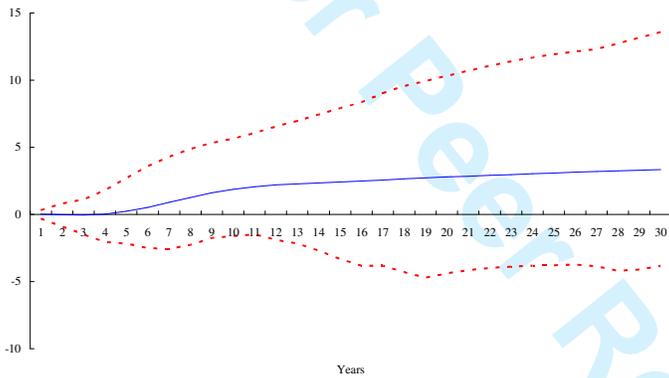


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**Chart 1.ga France - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



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



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

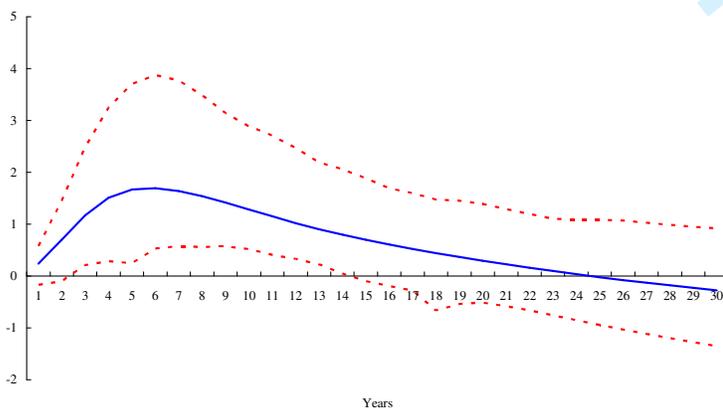


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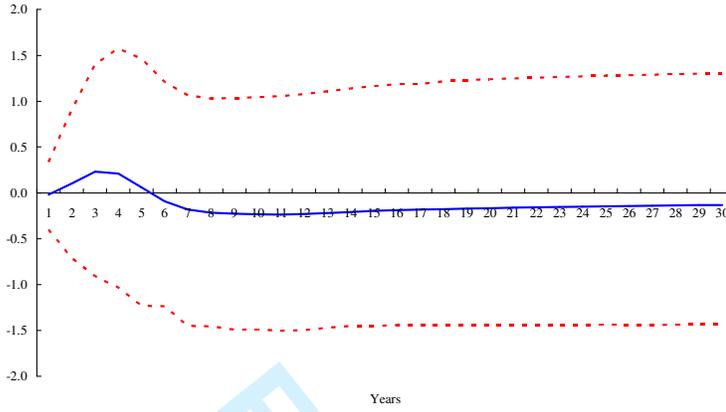


Chart 1.ia Greece - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment

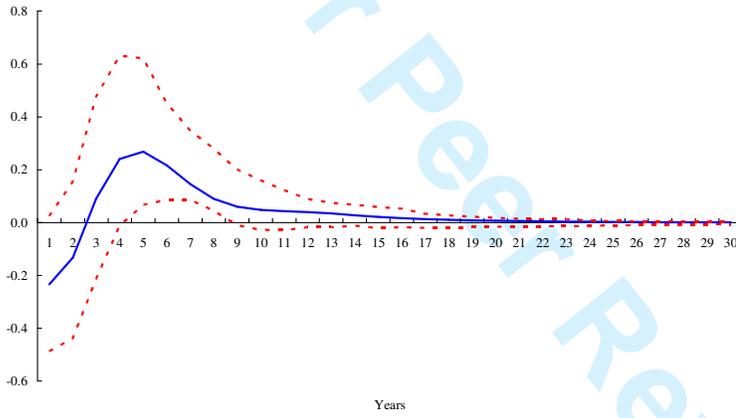
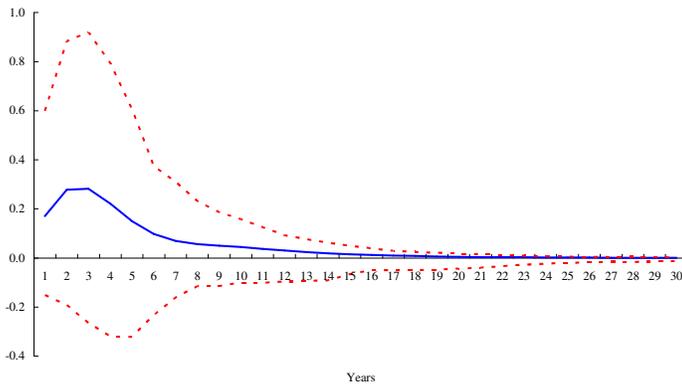
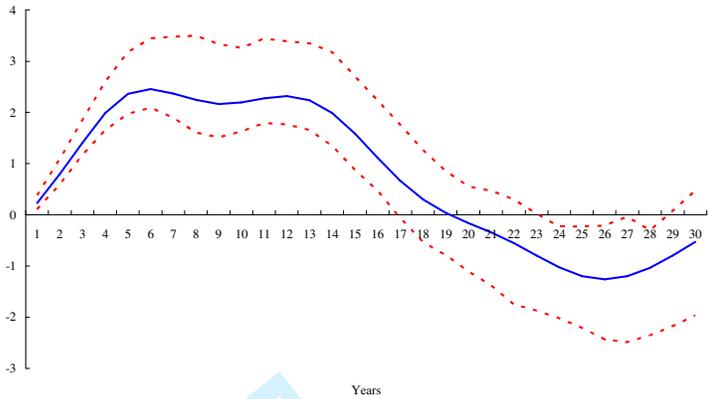


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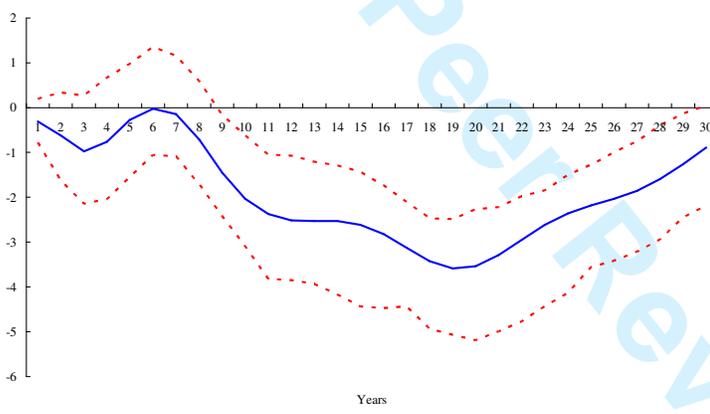


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**Chart 1.ja Ireland - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



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



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

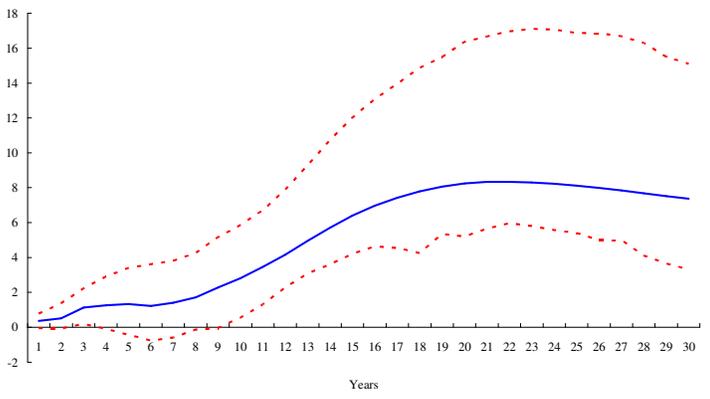


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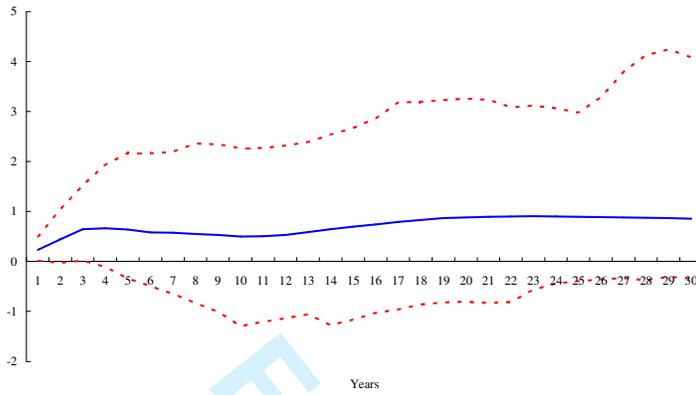


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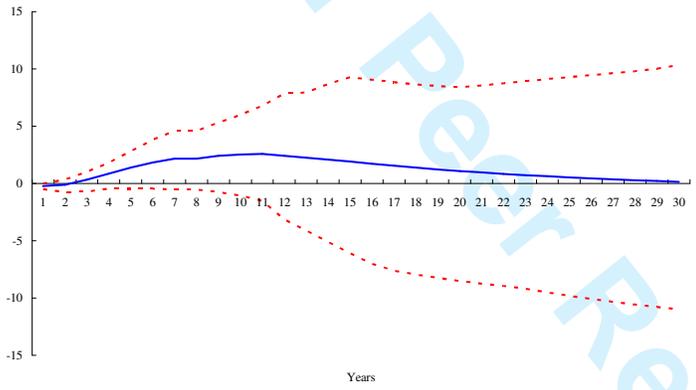
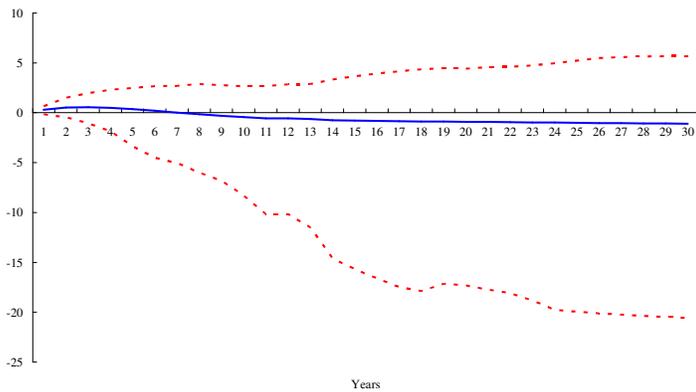
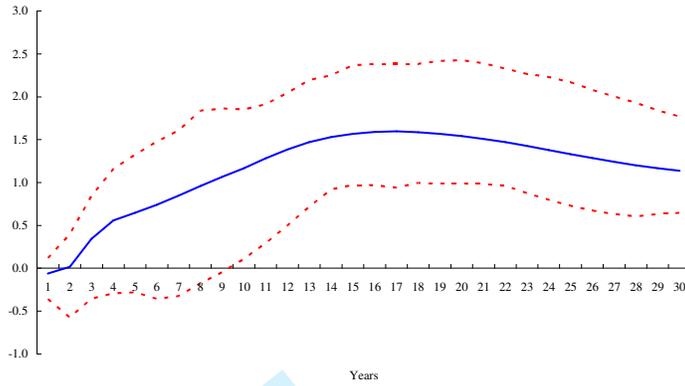


Chart 1.lb Japan - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment

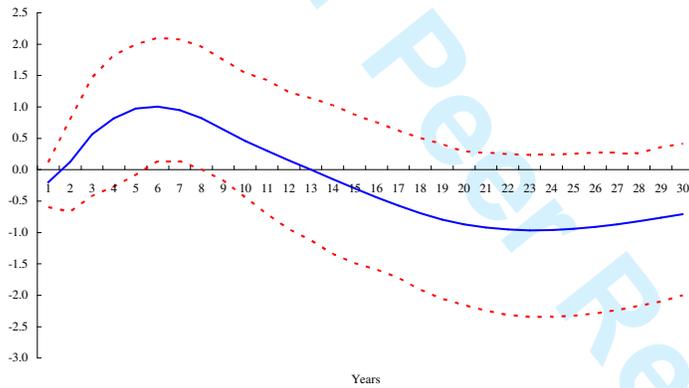


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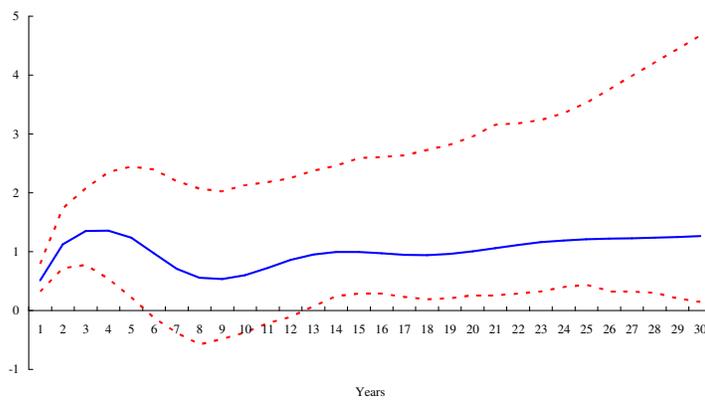
**Chart 1.ma Netherlands - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



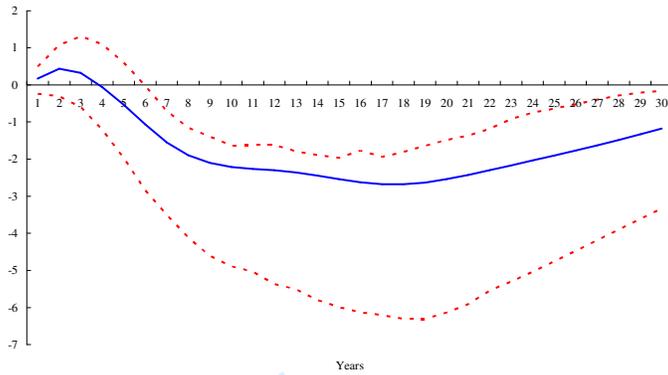
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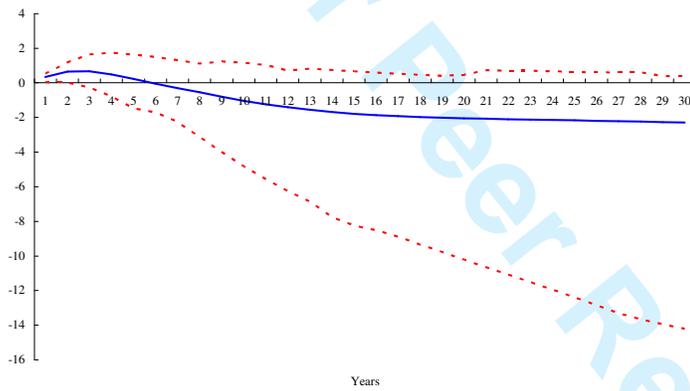
**Chart 1.na New Zealand - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



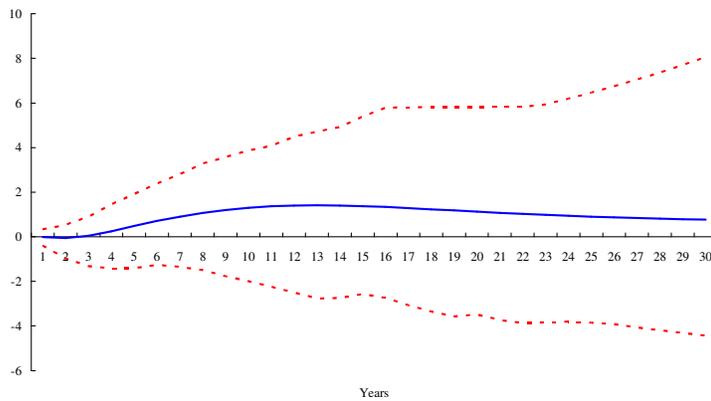
**Chart 1.nb New Zealand - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment**



**Chart 1.0a Norway - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



**Chart 1.0b Norway - Impulse Response of Private Investment to a 1 S.D. Shock to Public Investment**



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

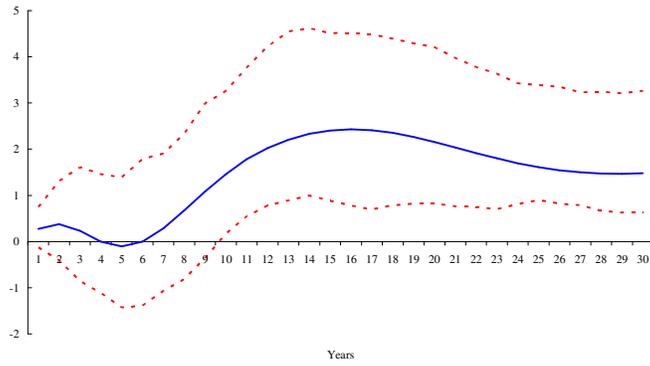


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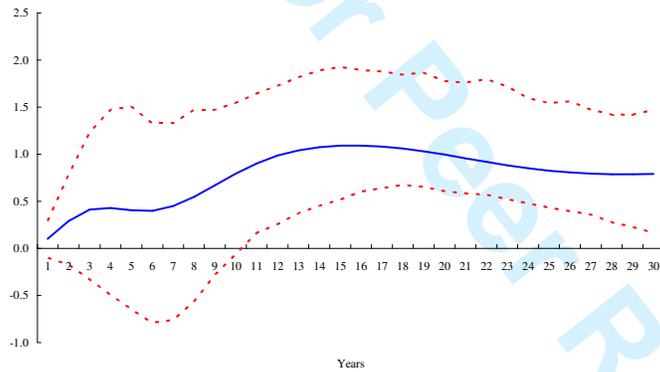


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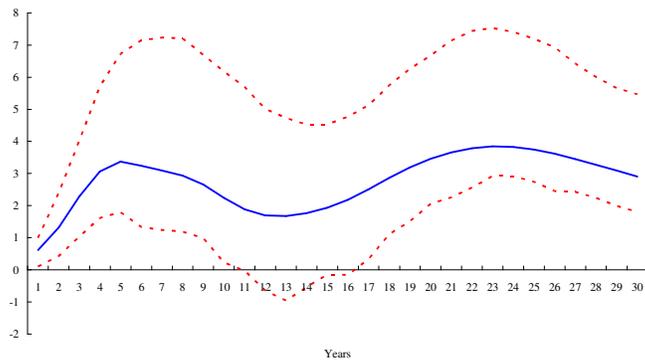


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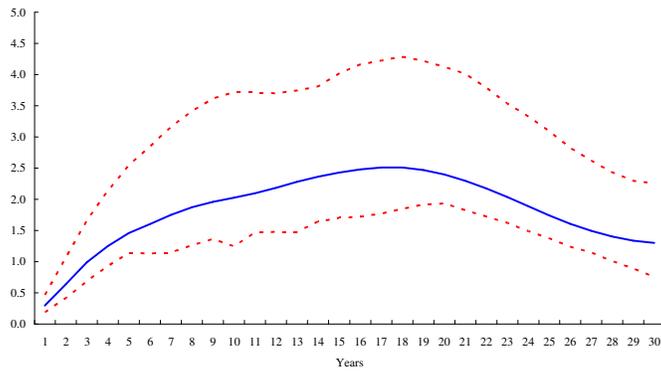


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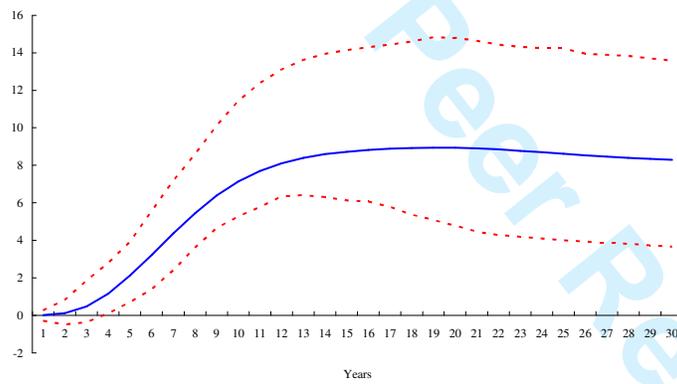
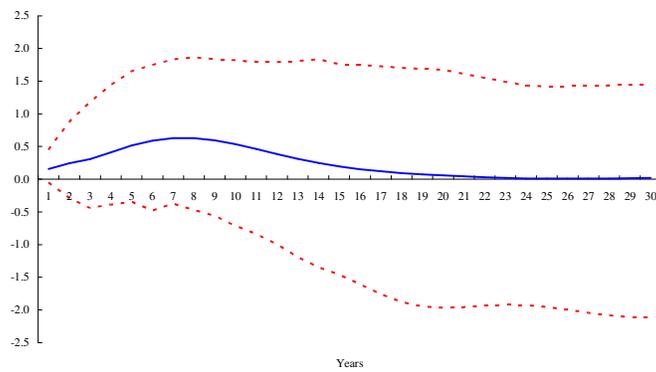
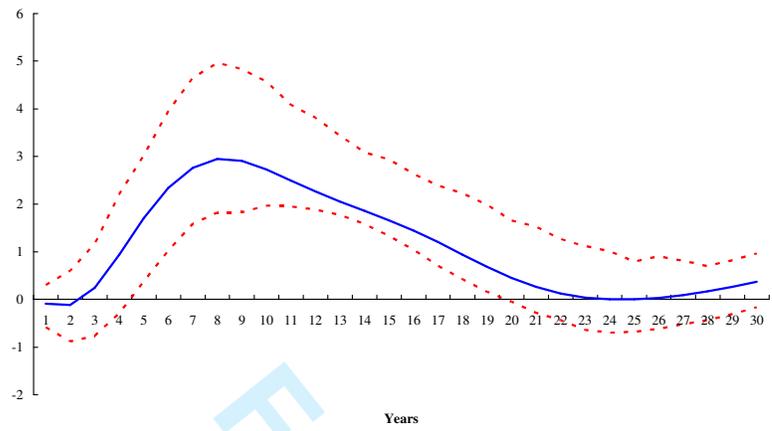


Chart 1.rb Sweden - Impulse Response of Private Investment to a  
1 S.D. Shock to Public Investment

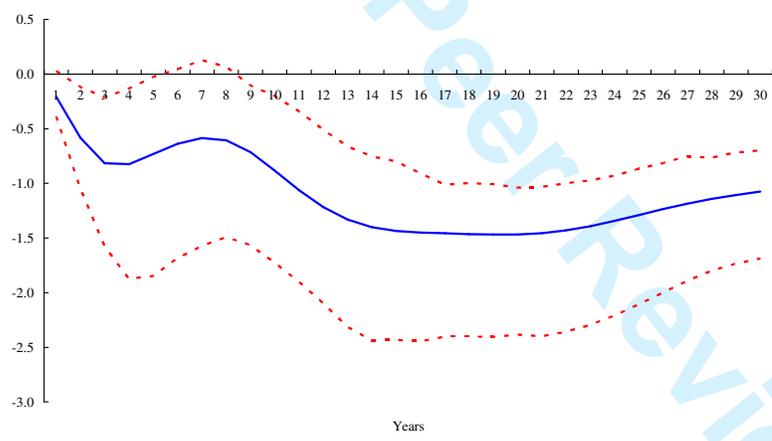


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**Chart 1.sa UK - Impulse Response of Public Investment to a 1 S.D. Shock to Private Investment**



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



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

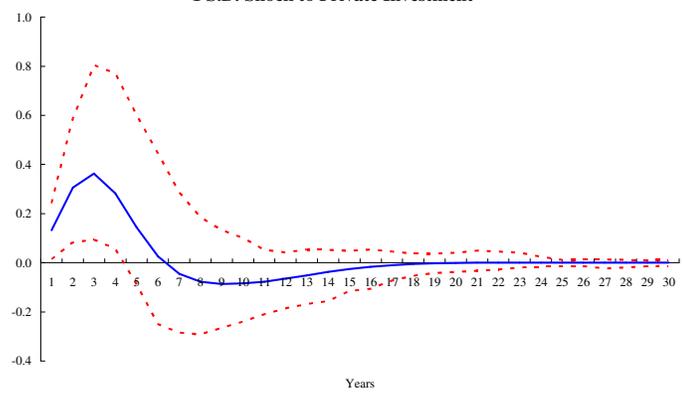
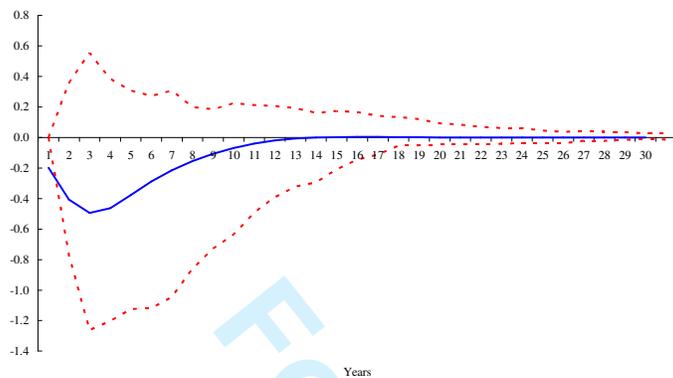


Chart 1.tb USA - Impulse Response of Private Investment to a  
1 S.D. Shock to Public Investment



**Table 1: Testing for Cointegration at Pool level ( $gk = \alpha + \beta pk$ )**

	<b>gk</b>	<b>pk</b>	<b>RES</b>
Levin, Lin and Chu t-test	1.31 (0.90)	1.86 (0.85)	0.14 (0.56)
ADF-Fisher Chi Square test Denmark	33.30 (0.76)	36.53 (0.72)	29.47 (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 1a: Testing for Cointegration at Country level ( $gk = \alpha + \beta pk$ )**

	<b>ERS</b>	<b>Ng-Perron</b>		<b>ERS</b>	<b>Ng-Perron</b>
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
<b>Critical Values</b>					
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 2: Dynamic OLS (-2,2) Estimated Coefficients ( $gk = \alpha + \beta pk$ )

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

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

Notes: *p* values are presented in parentheses