FISCAL POLICY AND INVESTMENT:
THE NEW SUPPLY SIDE ECONOMICS

Steve Dowrick
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Fiscal Policy and Investment: the new supply side economics

Steve Dowrick, Research School of Social Sciences, Australian National University

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Abstract

Recent evidence is reviewed which points to significant spillovers from the stock of public capital to private sector productivity. The productivity effect stimulates private investment in the medium term, overcoming short-term crowding-out. Cuts in public investment over the last decade may have sacrificed growth in favour of short-term fiscal balance. Evidence is also reviewed that social returns to investment in equipment and machinery exceed private returns, raising serious concerns about the Australian tax system which favours investment in housing and offices over investment in equipment.


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FISCAL POLICY AND INVESTMENT:
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Steve Dowrick
Economics Program
Division of Economics and Politics
Research School of Social Sciences
Australian National University

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Summary and Conclusions

Recent evidence from a wide range of studies suggests that the importance of investment has been under-estimated in the determination of medium-run growth rates. It appears that investment in the core public infrastructure and investment in equipment and machinery are particularly productive. There is a strong suggestion that substantial benefits can spillover from these investments to raise productivity across the private sector.

A series of econometric studies from David Aschauer, Alicia Munnell and others suggests that for the USA the publicly owned stock of capital in the core infrastructure of transport, communications and water services has had important spillover benefits onto private sector productivity. The decline in US public sector investment since 1975 has accounted for a substantial proportion of the well-documented slowdown in the growth of private sector productivity. Whilst the most recent studies are critical of Aschauer's pioneering work, and typically produce lower estimates of the size of these spillovers, they are unanimous in confirming their existence and significance.

These studies have also shown that the short-term crowding out of private sector investment by public investment is more than offset in the longer term by the positive productivity effect - in the medium term of three to five years public investment tends to crowd private investment in.

Preliminary studies on Australian data and on cross-country data have produced findings which are very similar to those reported for the USA. Cross-country analysis confirms that public investment in infrastructure raises private sector productivity and thereby stimulates private investment in the medium term.

Several important implications follow for macroeconomics. First, macro-modelling of fiscal policy is mis-specified to the extent that it concentrates only on short-term interest rate effects and crowding out. Public investment may crowd-in investment in the medium term and thus alter the dynamics of adjustment to macroeconomic balance. Second, a
welfare analysis of public spending and financing should take account of the positive spillovers from public capital in influencing the long-run growth path of the economy.

A separate series of studies by De Long and Summers have examined the mix of investment across a sample of OECD and developing economies over the period 1960-85. They suggest that the gross annual rate of return on investment in machinery and equipment is much higher than that on investment in dwellings and structures. Taking account of the faster rate of depreciation of equipment, they find that the net social return is still about twice as high as the net return on structures. They suggest that there may be significant beneficial spillovers from equipment investment which result from the transfer of ideas and experience gained by workers who learn new techniques and ideas as a result of implementing and adapting the technologies embodied in new equipment.

Critics have questioned both the empirical robustness of the De Long and Summers results and also their economic interpretation. There is some suggestion that their sample of countries may not be representative. Some have argued that their results may simply reflect differences in the timing of investments or the fact that rapid economic growth induces high rates of investment in equipment.

Although these empirical and theoretical arguments have yet to be fully resolved, this report presents some preliminary evidence which suggests that for a sample of 18 OECD countries over the period 1980 to 1990, the De Long and Summers results do stand up to the criticisms that have been levelled at them.

If these results are confirmed, there are important implications for Australian tax policy. Not only do Australian producers face relatively high prices for equipment investment compared to other OECD producers, but also the tax system strongly favours investment in housing and offices. There is a strong case that tax and tariff policies should be amended to prevent the diversion of resources away from investment in equipment and machinery.

1. Introduction: investment and new theories of economic growth

Investment is at the heart of the recent crop of models of endogenous growth. If it is possible to divert some part of currently produced output to increase capital stocks which contribute significantly to future production, then investment may contribute to long-run growth. This possibility was ruled out in the mainstream neo-classical models which dominated the thinking of the economics profession in the 1960s and 1970s. In these models, the marginal product of capital is typically assumed to dwindle to zero as the ratio of capital to labour increased. So there must come a point when the returns to a given rate of investment are sufficient to cover only the depreciation of the capital stock and the requirements of equipping new entrants to the labour force. In the optimising version of the model, accumulation is limited by the point at which returns to net investment chosen by forward looking households falls below their discount rate.

At their simplest, endogenous growth models assume that the marginal product of capital (reproducible inputs into the production process) is constant. As long as the discount rate is less than the marginal product, households will choose to invest and the economy will grow. If taxation and / or spillover effects reduce returns to private investment below the social rate of return, then fiscal policy can be used to stimulate investment and growth.¹

The potential benefits from correcting externalities apply even if endogenous growth is limited by diminishing returns. There are both short-run and long-run gains from increasing the steady state level of per capita consumption. The prospect of enhancing long-run growth prospects is, of course, attractive for policy analysts - but the case for public policy relies on the identification of spillovers and distortions rather than on whether growth in the long-run is endogenous or exogenous. Indeed, although endogenous growth appears to enhance the desirability of successful policy intervention, it also enhances the possible damage from mis-managed or mis-targeted intervention.

¹ Although this paper is concerned with physical investment, similar arguments apply to the accumulation of skills through education and training (including learning by doing) and on the accumulation of knowledge through research.
This paper concentrates on the size of returns to different forms of physical investment and the existence of significant spillovers. Two sets of recent papers have suggested that there is strong evidence of substantial spillovers emanating from particular types of investment. Both series have sparked fierce controversy which is only just beginning to reach the pages of the academic journals. The first set, associated primarily with Alan Aschauer, deals with the spillover benefits of public investment in the physical infrastructure of transport, communications and power supplies. The second set of papers by Bradford DeLong and Lawrence Summers distinguishes the returns to private investment in machinery and equipment from the returns to investment in structures, whether houses or offices or factories.

2. The social returns to investment in public infrastructure

There is now a substantial body of evidence and argument concerned with the benefits gained by private producers from the stock of public capital. These benefits are spillovers to the extent that the services of the public capital are not marketed. It is important to note that these studies ignore any benefits which accrue directly to consumers - benefits which may be particularly important in regard to public hospitals and schools.

It is of course not surprising that the public provision of infrastructure should create benefits for private producers. By the very nature of public goods, infrastructure such as roads and water supplies and communication networks which benefit consumers are likely to also benefit producers.

Aschauer's original motivation for investigating the returns to private producers appears to have arisen in relation to the debates of the 1970s and 1980s over fiscal policy and government deficits. He argues that these debates had been captured by the conflicting demand side and monetary models of Keynesians and New Classical theorists who were ignoring the supply side effects of public expenditure on infrastructure. Debates over the efficacy of public deficit spending in stimulating cyclical recovery, the old 'Ricardian equivalence' question, are missing an important point when they ignore the nature of the activities which the deficit is funding. If borrowing finances pure consumption then Ricardian equivalence may well hold; but this will not be so if deficits are funding public investments with significant spillover benefits.

Aschauer's evidence has extended beyond the debate over the stimulatory effects of deficit spending to encompass a wider debate about the desirability of expanding public infrastructure, however funded. Although his original papers were careful not to even attempt to judge whether the US public infrastructure is too large or too small in relation to some social optimum, his 1990 paper, quoted by Munnell, states that:

"Increases in GNP resulting from increased public infrastructure spending are estimated to exceed those from private investment by a factor of between two and five."

Later studies suggest that Aschauer may have substantially over-estimated the true return to public investment. Indeed, this perception has probably undermined general belief in the validity of his arguments. Subsequent studies, both in the USA and elsewhere including Australia, have come up with more modest estimates of the productivity of public capital. Nevertheless, these studies have unanimously found that the spillovers from public capital to the private sector are indeed positive and substantial.

Although we may quite rightly be sceptical of extravagant claims such as that quoted above, we should not be blinded to the fact that every subsequent study, often by authors quite critical of Aschauer's methods, has come to similar conclusions, albeit with more plausible estimates of the size of the spillover effects.

(i) Aschauer's evidence

The main thrust of Aschauer's evidence concerns the spillover effects on private productivity arising out of the public provision of a core infrastructure, which he defines as streets, highways, airports, mass transit systems, electricity and gas, water and sewerage. He uses
annual time series data for the USA from 1949 until 1985. In his first paper, he estimates the parameters of a constant returns to scale Cobb-Douglas production function, where private output, y, is a function of time, T, labour input, n, private capital, k, government capital, g, and the level of capital utilisation, cu. (All variables measured in logarithms, so the regression is linear). His principal regression result is:

| US private sector productivity and public non-military capital 1949-85 (Aschauer) |
|---|---|---|---|---|
| y = -2.42 +0.008T +0.35(n-k) +0.39(g-k) +0.43cu |
| (t= -21) | +4.6 | +4.9 | +16.2 | +12.3 |
| R²=0.976; DW = 1.79; |

If we take the point estimates, the elasticity of private sector output with respect to public capital is nearly 0.4, and highly significant statistically. The estimated output elasticity with respect to private capital is (1-0.35-0.39) = 0.26. These estimates imply that a large part, over three quarters, of the decline in US private sector total factor productivity since 1970 is attributable to the decline in the rate of growth of public infrastructure. It is this dramatic implication which has fuelled the subsequent controversy in the US over Aschauer's method and interpretation of his results.

Aschauer also disaggregates the components of the public capital stock and finds that the most significant contribution comes from the core infrastructure, which makes up 55% of non-military public capital and boosts private sector output with an elasticity of 0.24.

Some of the subsequent criticism was anticipated in Aschauer's own papers. An obvious point is that causation may run from productivity, proxying income levels, to the demand for public capital. Using lagged capital stocks as an instrument, however, he estimates an elasticity of 0.40 (t=15.4). Alternatively, causation might run from some unidentified factor, related perhaps to oil price shocks, which caused a downturn in both productivity and public investment. But he reports that the coefficients are stable around a break at 1967, the midpoint of his sample.

Another criticism is that he had not performed tests for cointegration of the regression time series. However, the high value of the Durbin-Watson statistic indicates that the residual is likely to be stationary, and he did find that the inclusion of lagged dependent and independent variables (approximating an error correction mechanism) did not significantly improve the fit of the regression.

In his subsequent paper (Aschauer, 1989b) he addresses the criticism that public infrastructure is merely substituting for private provision. The results support the neoclassical hypothesis that, holding constant the rate of return on private capital, there is a one to one reduction in private investment. In the short-run, therefore, he concludes that public investment crowds out private investment. But in the longer run, public investment raises the rate of return to private capital and stimulates private investment. After a period of around four years, private investment is estimated to rise above its base level and after ten years or so the crowding-in effect leads to a higher level of net capital stock.

(ii) Further evidence and criticism

a) Cross-section studies

Munnell (1990b) presents interesting results from a disaggregated study of pooled cross-section time series data for 48 states. Here the government infrastructure, g', is state or local, excluding federal government and military and the cyclical variable is the state unemployment rate, UN. Her principal result is:

| 48 US states x 1970-1988 annual data, excluding federal capital (Munnell) |
|---|---|---|---|---|
| y = 5.75 +0.59n +0.31k +0.15g' -0.007UN |
| (t= 39) | 43 | 30 | 9.0 | -4.7 |
| R²=0.993 |

Whilst the estimated elasticity is lower than in the aggregate time series study, the results are quite compatible if the missing federal capital stock has an elasticity of 0.15 or more. Much
of the criticism of endogeneity and causation is avoided by using cross-section data which breaks the feedback between productivity and incomes onto the demand for public infrastructure. Munnell also estimates a translog production function in order to pick up substitutability or complementarity between factors. Her results are eminently plausible. In particular, water and sewer facilities are strong complements to private capital. On the other hand, hospitals, schools and power plants - all of which have private sector counterparts - are strong substitutes for private capital.

She goes on to examine the determinants of private investment across states. Her results echo those of Aschauer's analysis of the aggregate time series data. Whilst public capital does substitute to some extent for private investment, this substitution is swamped by the boost to the marginal productivity of capital. The net effect is that a state which increases its stock of public capital will tend to encourage higher private investment as well. Moreover, raising the stock of public capital will also tend to raise employment growth. For every extra $1000 dollars of the initial public capital stock, private investment is estimated to rise by over $400 and employment growth to increase by 0.2 percentage points.

Munnell's analysis of public investment is particularly valuable because it disaggregates across states and by type of public capital. This approach reduces the likelihood of spurious correlation due to common time trends which may obscure the relationship between productivity and infrastructure in the aggregate data. On the other hand, by making states her unit of analysis, any spillovers of productivity effects across state boundaries are neglected. One might imagine, for instance, that investment in highways in one state could improve productivity in neighbouring states. So these estimates of the private productivity of public capital are probably lower bounds.

b) further time series evidence

Early support for Aschauer's findings on productivity spillovers came from the time series analysis carried out by Munnell as summarised in her 1992 paper in the Journal of Economic Perspectives. Her estimation procedure is similar to that of Aschauer, so it not surprising that her estimated elasticity, 0.31, is similar to his previous estimate.

Support for Aschauer's finding that public investment tends to increase private investment, at least in the medium term, comes from Erenburg (1993). He regresses US private sector investment on public investment, allowing for lagged effects and imposing rational expectations. He finds that the net effect of public investment is positive.

Further interesting work on the time series properties of the US data has been carried out by Lau and Sin (1993). They argue that a simple endogenous growth model must be characterised by constant returns to reproducible factors, which in this context means constant returns to private and public capital, for otherwise growth would be limited by decreasing returns (the Solow-Swan case) or it would be explosive (the case of increasing returns). They go on to explore the time series properties which are implied by endogenous growth and to test for cointegrating vectors following the work of Johansen. Their tests actually reject constant returns for the USA, but it is of some interest to note that one of their cointegrating vectors can be taken to imply an output elasticity for public sector non-military capital of 0.31. However, this result must be treated with caution because the underlying structural relationships are not properly identified by the Johansen technique.

modelling causality and the economic relationships

A principal criticism of Aschauer's studies is that although infrastructure investment is undoubtedly associated with growth in economic activity in general, hence with productivity growth, the causation does not necessarily run from infrastructure to productivity. Aschauer attempted to deal with this criticism by using lagged capital stocks as instruments in his aggregate time series regressions. Munnell does the same with her cross-state data and also finds that the strong positive elasticity is robust. So too do the other working papers which
Mannell cites which control for reverse causation and which control for input prices in estimating cost functions. There is however on further important point of econometric specification to be considered. Berndt and Hansson (1992) are very critical of the production function methodology which they dismiss as an 'engineering concept' with no economic content. Apart from the restrictions of the Cobb-Douglas functional form, which they argue should be replaced by some more flexible representation such as the trans-log form, they argue that the production function specification suffers inherently from problems of endogeneity. Mannell (1992) notes the criticism that the production function specification omits input prices which affect the utilization of both capital and labour, and output too, so biasing the OLS coefficients. Berndt and Hansson argue in favour of using the cost function approach which imposes an assumption of cost minimisation given exogenous factor prices. The regression analysis then uses factor prices as independent variables in estimating factor demands.2

This cost function approach is used by Berndt and Hansson who estimate short-run labour demand in Sweden, conditional on pre-determined capital stocks. Whereas the production function approach yields implausibly large estimates of the output elasticity of public capital, the cost function approach yields smaller estimates. Whilst these estimates suggest that public capital is over-provided in Sweden, they nevertheless confirm the existence of significant positive spillovers.

Despite concerns about the validity of the cost function approach, it is interesting to note that its use on US data still leads to qualified support for Aschauer's conclusions. Lynde and Richmond (1992) estimate a translog cost function to analyse annual time series data for the US nonfinancial corporate sector. They find that public capital is indeed a productive input in that it reduces costs in the private sector; moreover, public capital is complementary to, rather than a substitute for, private capital.

The most recent published analysis which deals with cointegration issues and specifies the underlying economic relationships is by Lynde and Richmond (1993) using a translog profit function, rather than the cost function used in their 1992 paper. They take account of intermediate input prices and apply new econometric techniques to deal with cointegration. All of the variables in their model, the ratio of factor payments to profits and the prices of factor inputs, exhibit non-stationarity - or, at least, their null hypothesis of non-stationarity is not rejected. They argue that conventional OLS estimation or single equation error correction models are not appropriate in the presence of non-stationary and endogenous variables. Instead, they use an estimator developed by Phillips and Hansen.

The principal finding is that public capital does indeed boost private sector profitability. The estimate of the average elasticity of private sector output is around 0.20, substantially below the earlier time series estimates of Aschauer and Mannell. Accordingly, they estimate that the reduction in public investment since 1973 accounts for rather less, around 40%, of the US productivity slowdown.

These findings are perhaps more plausible than those of Aschauer who attributes almost all of the slowdown to the decline in public investment, leaving little room for oil price shocks and other explanations. Indeed, Mannell (1992, pp 191-2) comments that:

"... the implied impact of public infrastructure investment on private sector output emerging from the aggregate time series studies is too large to be credible. It does not make sense for public capital investment to have a substantially greater impact on private sector output than private capital investment, particularly considering that so much public investment goes for improving the environment and other goals that are not captured in national output measures."

It is interesting then that the Lynde and Richmond estimates, more econometrically sophisticated than those of previous aggregate time series studies, should produce estimates

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2 There are, however, several criticisms of the use of cost functions. First, at the level of the firm it is not obvious that factor prices are exogenous. We expect wages to be determined by firms themselves, sometimes in conjunction with unions, to the extent that firms have some monopsony power or if they bargain with unions over wages or if labour effort is a function of the wage, as in the efficiency wage model. Second, even if individual firms are price takers in factor markets, the assumption of short-term cost minimization flies in the face of much of the economic analysis of the internal organization of the firm. Asymmetric information over employers' productivity and investment in training and long-run relationships imply that the short-run behaviour of many firms is likely to be a long way from the idealized model of the neo-classical firm facing competitive markets for homogeneous inputs with perfect information. The advantage of imposing economic models is that it gives more structure to the empirical analysis, but the cost is that the imposition of the wrong model may bias the results.
more in line with those of the cross-sectional studies across the US states (see Munnell, 1992, for a summary).

It seems fair to conclude from the US studies that the elasticity of private sector output with respect to public capital is at least 0.15 and possibly as high as 0.3.

(iii) Australian studies

Otto and Voss (1993) have replicated Aschauer’s study on Australian data. They too find that public capital has a strong positive effect on private sector output. Using annual data from 1966-1989, they estimate the impact of the public capital stock of general government on private sector output. This latter measure they construct from national accounts data on constant price output by industry groupings. Their estimate of the output elasticity for public capital is in the region of 0.40.3

Aschauer’s model has also been subjected to testing on Australian data by Antioch (1992) and Nhu (1993). Using an autoregressive error specification Nhu finds an estimated output elasticity of 0.40 for general government capital, the Hausman test fails to reject the hypothesis that the public capital stock is exogenous, and Granger causality tests suggest strongly that causation is indeed uni-directional, running from public capital to private output. Antioch finds broadly similar results, also noting that public enterprise capital has no impact on private sector productivity.

Otto and Voss (1993) are at pains to point out that their estimates do not necessarily imply that the public capital stock is too small. Indeed they point out that any such analysis would have to be embedded in a general equilibrium analysis which took account of substitution between public and private capital, the costs of raising public finance, differential resource costs, etc. Nevertheless, they report that the estimated marginal product of private capital is less than that of public capital throughout their sample period and has declined steeply since 1980.

In a preliminary version of a more recent paper, Otto and Voss (1994) have revised downwards their estimate for Australia of the private output - public capital elasticity. Using quarterly data and Hansen’s (1992) version of the Phillips-Hansen estimator, and extending their definition of public capital to include the capital of public enterprises, they find that the elasticity is nearer 0.20 than their previous estimate of 0.40. It follows that their estimate of the marginal private product of public capital is also reduced. But given Antioch’s earlier finding that public enterprise capital has no impact on private sector productivity, it is not surprising that Otto and Voss should find a lower spillover elasticity with respect to aggregate public capital. Indeed, the very reason that certain activities such as electricity generation are run as public enterprises rather than as direct public works is presumably that non-appropriable spillovers are relatively unimportant. The implication of the earlier study, that general government capital is underprovided, may then still hold despite the results of the later Otto and Voss study.

Figure 1 shows levels of public and private investment over the last three decades. In the latter half of the 1970s and again in the latter half of the 1980s there have occurred substantial cuts in the trend level of public investment - falling from around 8% of GDP in the 1960s to under 7% in the early 1980s and falling further to around 5% in the early 1990s.

Public sector investment cuts were imposed first, and most severely, on general government investment after 1975 - as illustrated in Figure 2. The main reductions of the 1980s were in the area of government enterprise, although general government investment fell too. These reductions in public investment have certainly helped to achieve the government’s aim of fiscal surplus in the late 1980s, but the impact on longer-run growth may well be damaging.

3 They subject their results to diagnostic testing and to alternative measurements of the key variables. Some of their variables are integrated of order one, but the estimated relationship displays co-integration. The results pass diagnostic tests for heteroscedasticity, functional form and normality. The parameters appear to be stable over a break in the last five years of the sample, when public investment was severely cut back, and over a break at the mid-point of the sample. The results are robust to the inclusion of the capital stock of public trading enterprises and to the addition of various variables capturing government consumption expenditures, public investment flows and marginal tax rates. Finally, they use lagged values to instrument the current capital stock and find no evidence of endogeneity.
be enhanced by reductions in wasteful expenditure. However, the decline in Australian public sector investment since 1985 has almost certainly involved reductions in the productive capital stock, so reducing the potential for future growth.

(iv) cross-country evidence

Results from a very recent study by Easterly and Rebelo (1994: p. 21) "seem to lend support from developing country experiences to Aschauer's (1989) contention that public spending on infrastructure has supernormal returns". Using a panel of 100 countries with observations over two decades, they find that public investment in transport and communication is strongly and positively associated with growth. This strong association is maintained when instrumental variables are used to take account of the impact of growth on investments, so there is a presumption that such infrastructure investment actually does induce economic growth.

This cross-section study also confirms the time-series evidence from the US, Australia and elsewhere that public investment does not crowd out private investment, rather that by raising the productivity of private capital it actually stimulates investment.

(v) Implications for economic modelling and for policy

A strong presumption has been created that public investment can be highly productive, not only in providing direct services to consumers of public roads, hospitals, schools etc. but also by raising the productivity of private enterprises who use directly or indirectly those public facilities. An immediate implication is that economic models which ignore these productivity benefits may underestimate substantially the benefits to economic growth of public spending on infrastructure projects. Moreover, the economic impact of government deficit spending may be much more positive than is typically allowed in models where government spending is defined to be unproductive. If deficits fund productive infrastructure investment,
the evidence suggests strongly that not only is there a direct positive effect on long-run output but also there may well be a significant crowding-in of private investment in the medium to long-term.

This suggests the emergence of a new supply-side economics. Appropriately directed public investment, whether funded by taxation or by borrowing, can stimulate growth in the longer-run. Seen in this light, the old debates between Keynesians and new classical economists over the short-run effects of government spending miss the point. Government spending is not the homogenous 'Q' of national accounting conventions. Rather, it matters crucially where the spending is directed.

In particular, there is reason to believe that post 1985 levels of public investment in Australia are below the socially efficient level, even though we would be hard pressed to quantify the exact extent of that shortfall. Munnell's (1992, p196) final warning bears repetition:

"Aggregate results, however, cannot be used to guide actual investment spending. Only cost-benefit studies can determine which projects should be implemented."

3. The social returns to investment in machinery and equipment

The current controversy over super-normal returns to equipment investment mirrors much of the debate over infrastructure capital. A series of provocative papers by two leading US economists has suggested that the real rate of return on equipment may be as high as twenty percent per year, with half of this return spilling over to total factor productivity. These estimates are strongly contested by others, although much of this debate has yet to reach the journals because the seminal papers were published as recently as 1991 and 1992.

(i) The case that equipment investment generates substantial spillover benefits

The two papers which propound the case for substantial spillovers from equipment investment were co-authored by Bradford De Long and Lawrence Summers. In contrast to

<table>
<thead>
<tr>
<th>Equipment investment and productivity growth, 1960-85, across 61 developed and developing countries</th>
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<tbody>
<tr>
<td>$g_y-g_l = 0.22E + 0.10I - 0.03g_l + 0.02P_G$</td>
</tr>
<tr>
<td>$(t=3.2 \quad 2.5 \quad 0.1 \quad 2.2)$</td>
</tr>
<tr>
<td>$R^2 = 0.369$</td>
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<tr>
<th>Equipment investment and productivity growth, 1960-85, across 25 high productivity economies</th>
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<tbody>
<tr>
<td>$g_y-g_l = 0.30E + 0.02I + 0.04g_l + 0.03P_G$</td>
</tr>
<tr>
<td>$(t=4.1 \quad 0.3 \quad 0.3 \quad 3.5)$</td>
</tr>
<tr>
<td>$R^2 = 0.719$</td>
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<tr>
<th>Equipment investment and productivity growth, 1960-85, across 21 OECD economies</th>
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<tbody>
<tr>
<td>$g_y-g_l = 0.15E + 0.04I - 0.36g_l + 0.02P_G$</td>
</tr>
<tr>
<td>$(t=3.0 \quad 1.3 \quad 2.0 \quad 7.5)$</td>
</tr>
<tr>
<td>$R^2 = 0.834$</td>
</tr>
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These results suggest that gross returns to investment in machinery and equipment are at least fifteen percent and probably over twenty percent per year, much higher than the ten percent or lower return on investment in other areas, primarily in residential and nonresidential structures.

De Long and Summers subject these results to stringent testing for spurious correlation, misspecification and reverse causation. Their results survive the addition of other variables explaining growth, such as schooling levels, public investment, the share of manufacturing in GDP and dummy variables for continents, although the coefficient on equipment investment falls to under 0.20 when schooling variables and political variables are included in an expanded sample of high productivity countries or when the sample is restricted to 21 OECD countries. Nevertheless, the estimated gross return on equipment is always more than double the estimated return on structures and substantially higher than expectations of normal real rates of return of around ten percent.

Figure 3 reproduces the De Long and Summers (1992, p. 171) scatter plot of the growth of labour productivity against the share of equipment investment in GDP for their extended sample of high productivity economies. 4

The estimates of a high rate of return to equipment investment are backed up by the addition of data on growth rates in the 1950s and the late 1980s. Moreover, even stronger results are obtained for a panel of observations on the very long run growth performance of seven countries - Argentina, Canada, Germany, Italy, Japan, the UK and the USA. Observations are taken for eight successive periods of around fifteen years each between 1870 and 1980. Controlling for country-specific and era-specific effects, the regression coefficient on equipment investment is 0.29 with a t-statistic of 3.5.

4 For around one half of this sample, including Australia, the authors did not have direct measures of real equipment investment from the International Comparison Project. For these countries, they estimated real equipment investment using estimates of real imports from the OECD between 1960 and 1985. Accordingly, the relatively high equipment share imputed to Australia may be illusory. Australian productivity growth is about average for the sample, but the imputed equipment share is the third highest in the sample, so Australia lies well below the predicted regression line. Lack of more accurate data on Australian investment, this observation for Australia should be treated with some caution. Indeed, OECD estimates for 1990 suggest that Australian equipment investment was below the OECD average, whereas investment in housing and non-residential construction was above average.
This intensive examination of specification and sample selection bias indicates that there is indeed a very strong association, or nexus to use the authors’ phrase, between economic growth and the level of investment in equipment and machinery. The next important question which De Long and Summers attempt to investigate is whether it can be established that causation runs from investment to growth, or vice versa.

Their strongest evidence on the direction of causality is the observation that fast growing countries with high equipment investment tend to have relatively low equipment prices. If the association between growth and equipment were demand driven, we would expect growth to induce higher prices for equipment by shifting the demand curve for equipment to the right and moving the economy up the supply curve. The evidence suggests instead that the association is supply driven with low equipment prices stimulating investment and growth.

Moreover, if causality ran from growth to investment, we would expect the estimated coefficient on non-equipment investment to be equally biased upwards. The fact that the estimated coefficient on equipment is consistently at least double that on structures lends strong weight to their argument.

Further evidence comes from the use of instrumental variables to estimate the investment-growth relationship. De Long and Summers use three separate instruments: the savings rate, the relative price of equipment and a measure on barriers on capital goods imports. In effect, they re-run regression (5) above on their extended sample of 47 high productivity countries. They substitute for total equipment investment only that portion which is explained by domestic savings, then that portion which is explained by relative prices, etc. In each case they find a strong and statistically significant effect with coefficients above 0.20.

Their final evidence that investment in equipment causes faster economic growth is derived from comparative case studies of Argentina and Japan. Peronist policies in the 1950s, continued through later decades by successor governments, had the effect of over-valuing the exchange rate and raising the relative price of machinery and equipment. De Long and Summers argue that Japanese policies had the effect of lowering the relative price of investment goods. Monopolistic high prices in the consumer goods sectors have been encouraged by Japan’s Liberal Democratic Party and LDP-client bureaucracies. On the other hand, the Ministry of International Trade and Industry has focused on achieving value for the purchasers of capital goods - blocking the effects of ‘politics-as-usual’ in the investment goods markets. Hence, Japan’s relative price structure favours equipment investment.

Having established to their own satisfaction that the strong association between equipment investment and growth is indeed driven by supply rather than demand factors, De Long and Summers proceed to examine the extent to which returns are captured privately as opposed to spilling over into total factor productivity growth. With equipment it is important to take account of depreciation, because equipment is typically much less durable than structures. This argument coupled with standard neo-classical assumptions about diminishing marginal returns implies that even if the private net rate of return on equipment is very high the impact on growth will diminish quickly over time and cannot produce the high gross rates of return which are observed over 25 year periods. The argument can be illustrated as follows.

Let us say that the net private rate of return is fifteen percent - much higher than we would expect to be the case. Assume the rate of depreciation is also fifteen percent. What are the effects of a permanent increase in the rate of investment? The gross return in the first year should be thirty percent. In the second year, the boost to gross output is diminished not only by depreciation of the additions to the stock of capital but also by diminishing returns (if any). It follows that the longer the time period over which the effects of investment are measured, the lower the observed gross return. De Long and Summers calculate that the gross rate of return in their example would be fourteen percent over a 15 year period, falling to 8 percent over 25 years.

The implication of this argument is that a substantial part of the observed gross rate of return on equipment investment must affect total factor productivity growth, i.e. it is a spillover benefit which does not depreciate or suffer from decreasing marginal productivity. De Long and Summers estimate that the net social rate of return to equipment investment is of the
order of twenty percent, with approximately ten percent in privately appropriable value created through capital deepening and the rest spilling over to other producers.

The economic mechanism by which these spillovers are transmitted is one of the weaker parts of the De Long and Summers analysis. They rely on a rather loose description of technical progress operating through learning by doing. New equipment is essential in that it provides the opportunity for producers to experiment with new techniques of production. The knowledge created by the interaction of new equipment and experience cannot be contained easily within the investing and experimenting firm. Outsiders may be able to directly observe both the work processes and products, or to infer them from reverse engineering. Moreover, worker mobility implies that benefits will spill over to firms who 'poach' the employees of successfully investing and innovating firms.

This spillover mechanism is certainly plausible. But it implies that equipment investment alone is not sufficient to generate large social returns. If the producers are not able and motivated to experiment and to learn from experience, then there may be little benefit from new equipment. This suggests that there may be important interactions between equipment investment on the one hand and policies and institutions which encourage experimentation and learning on the other hand. So education may be important, not only in producing a workforce which is capable of learning but also one which is interested in learning. Thus both the level of education and its bias in favour of or against technological creativity should interact importantly with incentives to invest in new equipment. Other important interactive variables might include the structure of industrial relations, the implicit commitment between employers and employees to long-term relationships, job flexibility, incentives for innovation and other elements of 'corporate culture' which encourage or discourage ideas and learning.

De Long and Summers' policy conclusions are not undermined by these arguments, rather the spillover mechanism described above suggests that their policies need to be augmented by policies designed to foster creativity and learning by those involved in production. Their principal policy recommendations are worth repeating.

- First, the tools which might be used to tip the playing field in favour of equipment investment should rely on market incentives rather than on command planning. In particular, protectionist policies which boost domestic monopoly prices for capital goods and raise the price of imported equipment should be avoided.
- We should also avoid tax policies which are biased in favour of assets which can be financed more easily out of loans rather than equity. Immoveable and long-lived structures which provide collateral for debt are then favoured over short-lived, firm-specific items of equipment.
- Labour market policies which discourage substitution of labour by capital should be avoided.
- Governments can positively encourage investment by policies to increase national saving.
- Reductions in taxes on new equipment, especially incremental investment tax credits, should be used to stimulate investment.

(ii) Criticisms of the equipment spillover hypothesis

Three principal lines of criticism have been levelled at De Long and Summers. First, there is disputation over whether their evidence of a strong association between equipment and growth is robust. Second, even if the association is accepted, there are still important questions over the direction of causality. Third, it can be argued that the evidence is compatible with a causal story where equipment investment produces normal social returns but its timing induces the 'spurious' correlations which are observed in the long-run data.

The empirical robustness of the association has been questioned by Alan Auerbach and co-authors. Whilst there is an evident positive correlation, they argue that it is strongly biased by the inclusion of Botswana. Omitting this one influential observation, the coefficient on equipment in equation (4) falls from 0.223 (t=3.2) to 0.157 (t=2.1). Furthermore, for the 18
OECD countries in this sample, there is no significant correlation. The partial regression correlation, controlling for private investment, etc. also fails to show a significant correlation, with a coefficient of 0.028 and a t-statistic of 0.3. This seems surprising when compared with Summers and De Long's subsequent (1992) finding of a significant correlation in their extended sample of 21 OECD countries. Auerbach et al. argue, p. 12:

Their higher estimate reflects the combined effect of adding three new OECD countries to the sample, revising the values of $E$ and $F$ for the original sample countries, redefining $F$ to include transportation equipment, and replacing the level of GAP with its natural log.

The fragility of the De Long and Summers results to their sample selection procedure is certainly worrying. They could certainly reply, however, that their procedure of selecting countries on the basis of their ex ante level of productivity, i.e. 1960 levels, is a better procedure than choosing a sample from the OECD which is potentially biased by ex post selection of successfully growing countries like Japan and the exclusion of countries like Argentina which had high productivity levels in the 1950s but failed to capitalise on them. Whereas Auerbach et al. argue that countries like Argentina should be excluded from the sample because they do not fit the neo-classical modelling assumptions of common production functions and market driven investment, De Long and Summers could reply that the comparison of the Argentine and Japanese experiences (as in Figure 2) is exactly the natural experiment which we should wish to capture in a regression sample.

This debate over sample selection will, no doubt, run on. The commentators reported in the 1992 Brookings Papers seemed inclined to accept the evidence of a strong association and to concentrate their criticism on the questions of causation and timing. I present new evidence in the next section which suggests that the association is indeed strong for the OECD sample in the 1980s.

The reported arguments on the direction of causation do not break any new ground, having been already anticipated by the authors in their paper. Criticisms were made, however, of the validity of the instrumental tests that De Long and Summers rely on in large part in their attribution of causality to investment. Two arguments are put forward as to why the linclpin of the causality argument, the negative correlation between equipment prices and quantities, might not reflect the supply side shifts which the authors have asserted. Martin Weitzman suggests that the relative prices might instead reflect differences in market structure in the capital goods industries, with oligopolistic industries rationing supply and raising prices, whilst monopolistically competitive industries would produce higher quantities at lower prices. It is not clear, however, that this market structure argument should undermine the De Long and Summers thesis. From the point of view of the users of capital goods, it does not matter whether cheaper capital equipment comes from tax incentives or from technical advance or from changes in industry structure. In any of these cases, the negative correlation between prices and quantities identifies the demand curve.

Probably a more telling point comes from Gregory Mankiw who suggests that the negative price quantity correlation might reflect the relative price of traded versus non traded goods, with fast growing countries having higher prices of non traded goods, hence the lower relative price of equipment. In this case, the supply side causation would be undermined.

Mankiw's argument is worth considering. It is certainly the case that as economies develop, and real wages rise in line with per capita GDP, the price of non-traded and labour intensive goods tends to rise relative to capital intensive traded goods. Indeed, De Long and Summers' own evidence tells just this story - as do the recent OECD evidence summarised in the next section. For identification purposes, then, the appropriate instrument which they should use is not the raw relative price of equipment but the deviation of the price from the price predicted for a country at that stage of development - i.e. the deviation of the observation from the regression line drawn in Figure 3. There is some indication that the countries with lower than predicted investment prices, such as Japan and Israel, do indeed have high equipment investment whereas countries with higher than predicted prices, such Italy and Chile, do have lower investment shares. If this impression is correct, then Mankiw's criticism is not supported. De Long and Summers (1992) do indeed say that the instrument they use is the deviation of the real price of equipment from its expected value, without, however, specifying how they estimate it. If indeed they have controlled for
income levels, then their procedure is probably robust to the Mankiw criticism. I proceed in
the next section to analyse some recent OECD data for 1980 and 1990 to investigate these
points further.

A final criticism which was made by De Long and Summers' discussant, Andrew Abel, is
that their results could have been produced by a surge of investment in the last few years of
their sample, even though the net rate of return could have been normal. Basically, if all the
investment came at the end of the period, real depreciation would not have much affect
within the observed time frame and the gross returns would exaggerate the real long run
returns.

Whilst this criticism is probably technically correct, Abel presents no evidence that such a
surge of investment did actually occur to bias the results. Perhaps more pertinent are his
concerns that the theoretical framework of growth analysis has not been properly developed
to deal with the situation where innovation is concentrated in the sectors of the economy
which are producing the machines and equipment for the rest of the economy.

4. Exploratory analysis of OECD equipment investment, prices and growth 1980-
1990.

I present here some preliminary analysis of the equipment investment / price / growth nexus
using data from OECD (1992) which covers 24 countries for 1990 and from UN (1985)
which covers 18 OECD countries for 1980. The data appendix lists my estimates of real
equipment investment shares, the price of equipment relative to the price of GDP, and the
growth rate of real per capita GDP.

Figures 4 to 6 show scatter plots of real equipment shares in GDP, real prices and per capita
GDP. Equipment shares are strongly negatively correlated with prices. Japan's extremely
high equipment share in 1990 is an outlier, but even without this observation the negative
correlation is very strong. Australia's equipment investment in 1990 is slightly above
average at just over eight percent of GDP, although the real price of equipment is slightly
above the weighted OECD average. Although not shown here, it is of interest to note that

the real Australian price of construction investment, particularly the price of residential
investment, is some twenty percent below the OECD average.
The real price of equipment is also negatively correlated with income levels while the equipment share tends to rise with income. Australian prices and quantities of equipment investment appear to be fairly close to the average levels for countries with medium high incomes.

I use this data to repeat the basic De Long and Summers regressions. I can only use those 18 countries for which international price data are available for 1980. Some preliminary results are reported in the Table below. Note that I do not report the intercept as it has no economic interpretation since growth rates are expressed relative to the US. The regressions do not control for the growth of the labour force.

Table 1: Regressions explaining growth in per capita GDP for 18 OECD countries 1980-1990.

<table>
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<tr>
<th></th>
<th>1. OLS</th>
<th>2. OLS</th>
<th>3. 2SLS</th>
<th>4. 2SLS</th>
<th>5. OLS</th>
<th>6. OLS</th>
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<tr>
<td>equip. investment 1980</td>
<td>0.335 (2.1)</td>
<td>0.519 (1.8)</td>
<td>0.267 (1.6)</td>
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<tr>
<td>equip. investment 1980/90 av.</td>
<td>0.0435 (2.2)</td>
<td>0.51 (2.1)</td>
<td>0.302 (2.1)</td>
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<td></td>
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<tr>
<td>non-equip. investment 1980</td>
<td>-0.14 (-1.6)</td>
<td>-0.19 (-2.4)</td>
<td>-0.15 (-1.7)</td>
<td>-0.21 (-2.2)</td>
<td></td>
<td></td>
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<tr>
<td>log real GDP per capita 1980</td>
<td>-0.020 (-2.2)</td>
<td>-0.022 (-2.8)</td>
<td>-0.025 (-2.2)</td>
<td>-0.024 (-2.7)</td>
<td>-0.021 (-2.2)</td>
<td>-0.022 (-2.5)</td>
</tr>
<tr>
<td>R²</td>
<td>0.248</td>
<td>0.432</td>
<td>0.179</td>
<td>0.421</td>
<td>0.169</td>
<td>0.246</td>
</tr>
<tr>
<td>s.e.</td>
<td>0.0102</td>
<td>0.0089</td>
<td>0.0107</td>
<td>0.0090</td>
<td>0.0108</td>
<td>0.0103</td>
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<tr>
<td>Hausman test (x²)</td>
<td>-0.80</td>
<td>-0.36</td>
<td>-0.7</td>
<td>-0.5</td>
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</table>

Notes: 1. The Hausman test is the t-statistic from the addition of the residual of the instrumenting equation. The instrument are the log of real GDP per capita 1980 and the real price of investment 1980. The same instruments are used in the Two Stage Least Squares estimation.
2. All regressions pass tests for heteroscedasticity and functional form.

I report results for both the equipment share in 1980 and the average of the investment shares in 1980 and 1990. The estimated coefficients are higher than those estimated by De Long and Summers for the period 1960-85. This is to be expected since they argue that over shorter periods the gross returns to equipment investment will reflect high rates of depreciation. There are two main points of interest. First that the coefficients on equipment are much higher than those on investment in structures, which are in fact estimated to be negative. Second, the Hausman test suggests that endogeneity is not a problem. When two stage least squares is used, the coefficients on equipment investment actually rise.

These results do tend to support the De Long and Summers argument over those of their critics who have criticised their avoidance of the 18 country sample and over those who have claimed that the high coefficients on equipment investment reflect reverse causation. Given this evidence, it is important to examine the potential bias imparted by the Australian tax system in influencing investment choices.

Pender and Ross (1993) find that despite major reforms to the Australian tax system over the last decade, there remain substantial distortions. For instance, with an annual inflation
rate of three percent, the effective tax rate for a local corporation investing in equipment is nearly double that on investment in buildings and nearly four times the effective tax rate for investment in owner-occupied housing. These rates are listed in Table 2.

Table 2
Effective Tax Rates for Investment - from Pender and Ross (1993) Tables 5&6
(statutory tax rate = 39%, inflation = 3%)

<table>
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<tr>
<th>ownership</th>
<th>asset</th>
<th>real effective tax rates (%)</th>
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<tr>
<td>owner-occuper</td>
<td>housing</td>
<td>11.4</td>
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<tr>
<td>negatively geared rental</td>
<td>housing</td>
<td>-0.8</td>
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<td>locally owned company listed on the ASX</td>
<td>machinery</td>
<td>42.5</td>
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<tr>
<td></td>
<td>buildings</td>
<td>27.6</td>
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5. Concluding comments

The new supply side economics focuses on medium-term growth rather than on the short-term fluctuations of the business cycle. There is strong evidence that some components of aggregate investment have substantial spillover benefits. Investment in public infrastructure is an obvious case where spillovers are to be expected, and there is unanimous evidence from Australian and other studies that such spillovers are indeed substantial, although disputes remain over their exact size.

Given the sharp reduction in Australian public investment, particularly general government investment, over the last decade, there is a strong presumption that the general government capital stock has fallen below its socially efficient level. This evidence supports calls for increases in government spending on infrastructure, and/or tax concessions for appropriate private provision, by adding long-run productivity gains to the possible short-term benefits of stimulating aggregate demand in an economy still suffering from gross under-utilisation of labour.

Perhaps more surprising, and certainly more contentious, is the cross-country evidence that investment in equipment and machinery also provides substantial spillover benefits. The implied mechanism is one of learning by doing associated with the introduction of new equipment, learning which the innovating firm cannot prevent leaking out to competitors. This evidence needs to be examined more closely, complementing existing cross-country studies with detailed time-series analysis. Nevertheless, the current weight of evidence is strongly suggestive that some such spillovers probably do exist. If so, the current tax bias against corporate investment in equipment is a matter for concern. There is a strong presumption that if effective tax rates are to vary across categories of investment, they should be lower for those assets which generate spillover benefits. At the very least, then, the tax system should be amended to reduce the dis-incentive to invest in machinery and equipment. If confirmatory evidence on the claimed spillover benefits is forthcoming, then a case can be made for tilting the tax rates further.
Data Appendix: equipment investment in 24 OECD countries 1980 and 1990

$y = \text{per capita GDP relative to US @ international prices for 1980, in 1990 $ @ OECD prices for 1980.}$

e = \text{real expenditure share in GDP of machinery and equipment investment.}$

$p = \text{price of investment relative to price of GDP (OECD=1).}$

c = \text{real expenditure share of construction investment (OECD=1).}$

g = \text{growth of per capita GDP, annual average 1980-1990, relative to USA.}$

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<tr>
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<th>y80</th>
<th>e80</th>
<th>p80</th>
<th>c80</th>
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<td>19067</td>
<td>0.077</td>
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Centre for Economic Policy Research
The Australian National University
Research School of Social Sciences, Canberra ACT 0200
Tel: 61 2 6242247, Fax 61 2 62493051

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