Sources of Productivity Growth at Aggregate and Disaggregate Levels

by

Kevin J. Fox

The University of New South Wales
Centre for Applied Economic Research
& School of Economics
Sydney, NSW 2052, Australia.
E-mail: K.Fox@unsw.edu.au
Fax: +61-2-9313-6337
Tel: +61-2-9385-3320

Presentation Prepared for the Productivity Perspectives 2006 Forum
23 March 2006, Canberra

Summary

1. The role of high-tech capital in driving productivity growth.

2. The role of public capital in driving private productivity growth.

3. Sectoral, regional and aggregation issues. Should Sydney pay for Brisbane's roads?

4. Issues in measurement and possible ways forward.

Note: There are similar issues relating to high-tech and public capital, such as the following:

- Network externalities may mean that local high-tech investment has positive effects country wide, e.g. new computer system at the head office. Same with public capital; highway infrastructure would be expected to have positive spillover effects.

- Alternatively, high-tech investment and public infrastructure may have strictly local benefits ("point infrastructure").

May also be overlap; public wireless network for downtown Philadelphia.

How to Measure Aggregate Productivity?

Figure 1: Productivity Growth, ABS Data

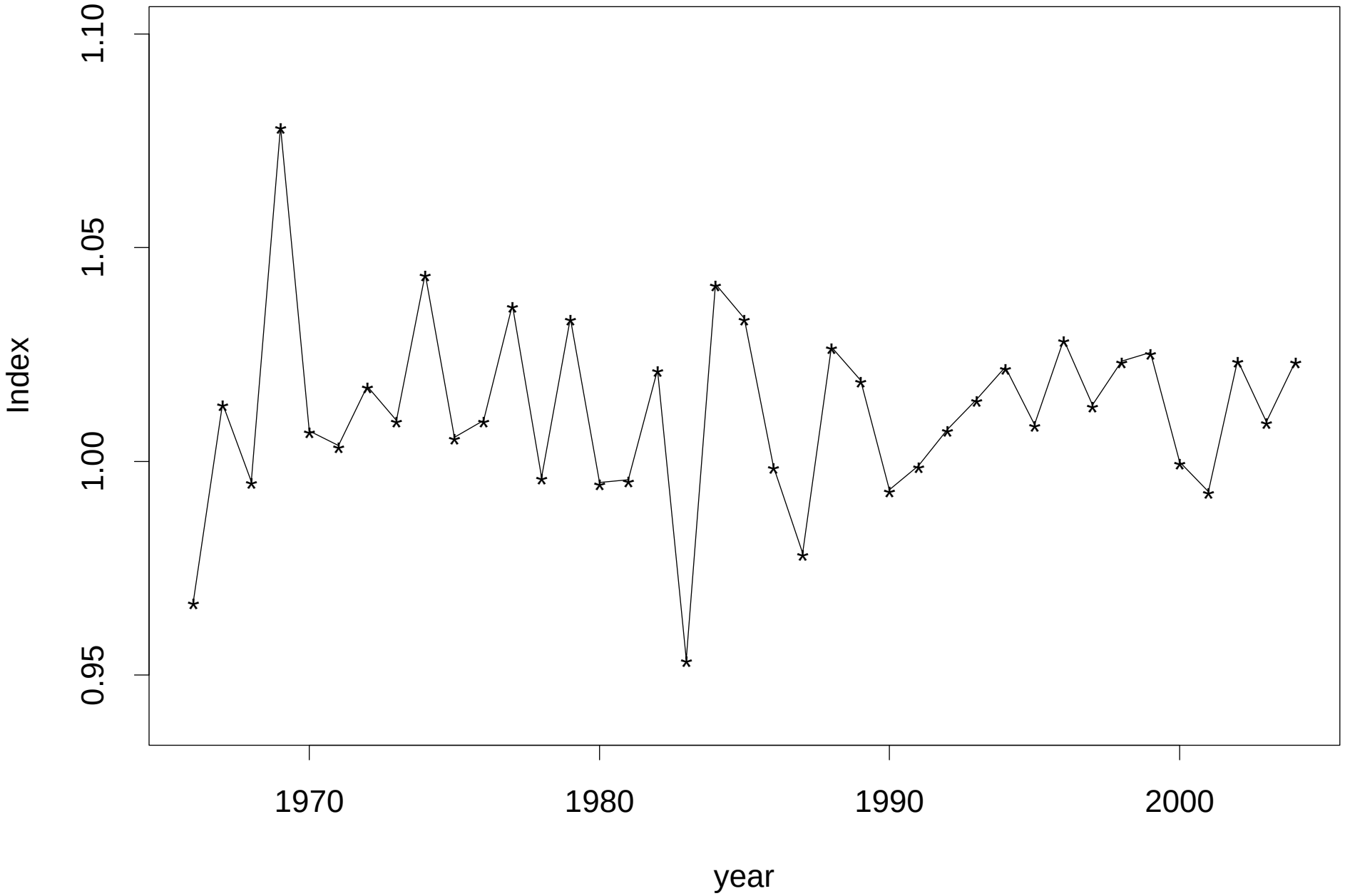

Figure 2: Productivity Growth, Diewert-Lawrence Data

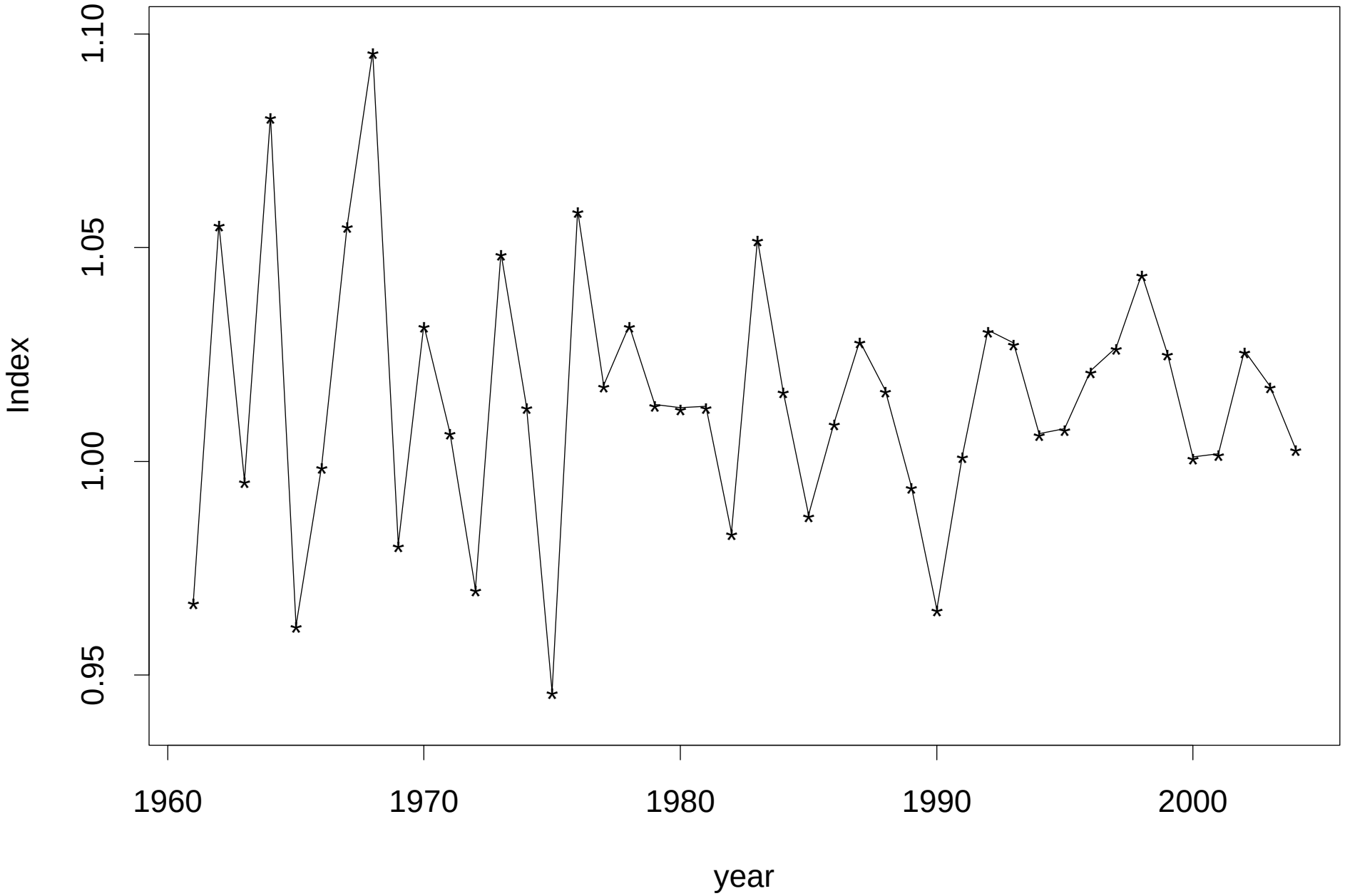

Table 1: Total Factor Productivity Growth, ABS versus DL

	ABS		DL	
	Mean	s.d.	Mean	s.d.
1966-2004	1.012	0.022	1.015	0.028
1966-1985	1.013	0.028	1.017	0.035
1986-2004	1.011	0.014	1.013	0.018

NB: A mean value greater than one implies positive TFP growth, while a value less than one implies negative TFP growth. The mean value less one times a hundred gives the average percentage growth in TFP. "s.d." denotes standard deviation. ABS refers to the official productivity growth series reported by the Australian Bureau of Statistics, while DL refers to productivity growth from the Diewert and Lawrence (2005) database for Australia.

High-tech Capital and Productivity Growth

1. Much interest due to the "Solow productivity paradox".

2. Recent productivity surge in U.S. often attributed to high-tech capital investment.

3. U.S. is a producer of high-tech capital — productivity from production or use of high-tech capital?

4. Daveri (2002): "It looks as though the celebrated 'Solow paradox...has fled the USA and come to Europe."

Some Australian Evidence High-tech Capital

Connolly and Fox (Economic Inquiry, 2006):

1. 11 sectors, including aggregate 'Market Sector,' 1965/66-2001/02.

2. There is some evidence of a relationship between productivity and high-tech capital use at the Market Sector level of aggregation.

3. At the individual industry level, benefits of high-tech capital not evenly spread across the economy. Positive relationship for:

- Wholesale and Retail Trade
- Finance and Insurance
- Accommodation Cafés and Restaurants
- Agriculture

4. For Electricity, Gas and Water, some evidence of a negative relationship.

5. Somewhat surprising results. Positive relationships found in service industries where output measurement is generally thought to be problematic.

Some Possible Future Research Directions

1. Study of Education, Health and Government sectors.

2. Explicitly model the Internet and e-commerce.

3. Policy implications if benefits of high-tech capital not spread evenly across the economy.

Public Capital and Private Productivity

1. Aschauer (1989): Relatively slower growth in public capital accumulation in 1970s and 1980s was largely responsible for the private sector productivity slowdown.

2. Wide range of estimates of output elasticities of public capital in the literature.

3. Aggregate production function and cost function specifications common.

4. Evidence suggests very high estimates of the elasticity of private output with respect to public capital, 0.35 to 0.45. (Aschauer, 1989; Munnell, 1990; Otto and Voss, 1994).

5. Spurious regression, endogeneity and causality issues examined in considerable detail.

6. Estimates using more sophisticated analysis of time series data typically half these estimates. Wide range of estimates in the literature, some not so sensible (Berndt and Hansson, 1991; Swedish data). Often constrained by lack of data.

7. Otto and Voss (1996): "While it is possible to imagine circumstances where public infrastructure induces economic growth in the private sector, it is also clear that existing empirical studies do not shed much light on the likelihood of such outcomes."

8. Otto and Voss (1998): Declining growth in public capital in Australia can be explained by the rising price of public investment goods relative to private investment goods; may reflect higher quality specifications.

9. Aggregate economy results may mask what is happening at sectoral level. Connolly and Fox (2004): Sectoral results for Australia (11 sectors, 1965/66-2001/02). Positive and significant impact of public capital on private MFP for Manufacturing, and Wholesale and Retail.

10. Aggregate empirical results suggest much higher return to public capital than suggested by cost-benefit analysis of individual projects — externalities or aggregation effects?

Regional Issues

1. Morrison and Schwartz (1996): State-level data for U.S. manufacturing. Infrastructure investment provides a significant return to firms, and augments productivity growth.

2. Haughwout (1998): "[I]t is important to distinguish investments in public goods which add to the productive capacity of the nation as a whole from those that simply provide advantages to some places over others."

3. Boarnet (1998): California data, 1969-1988. "The data show that changes in county output are positively associated with changes in street-and-highway capital within the same county, but output changes are negatively associated with changes in street-and-highway capital in other counties."

4. Because the aggregate production function approach is a partial equilibrium approach and ignores local price effects, it "cannot identify the productivity of public goods" and "national policymakers must avoid using its results in the formation of national investment policies." (Haughwout, 1998)

5. "[T]he public investment decisions we observe are the result of local political processes, and may not be designed to maximize private sector economic returns." (Haughwout, 2002)

Aggregation

1. Divergence of results using aggregate (pubic and high-tech capital) and regional data (public capital) may be due to aggregation effects.

2. Returns to scale aggregation (Basu and Fernald, 1997; Diewert and Fox, 2004).

3. Simple cost-benefit analysis for public capital can yield quite different results depending on the level of aggregation.

Further Issues

1. High-tech capital investment may generate consumption services, e.g. internet browsing at work!

2. Public sector capital is not only an input into private sector production. Produces consumption services, e.g. roads, hospitals, schools. May be more important as input into development of human capital.

3. Thus, not all public capital is equal. Same for high-tech capital. Policy choices.

4. "Because residents vote and firms do not, it is perhaps unsurprising to discover that the marginal public investment dollar provides larger benefits to households than to firms." (Haughwout, 2002)

5. Little guidance on the optimal levels of public sector and high-tech capital. Most studies use static partial equilibrium framework. Mixed evidence.

6. "[R]ecent disaggregated studies suggest that the structure of the government budget has much more impact on growth outcomes than does the size of the budget." (Grimes, 2003)

7. Efficiency of use of public and high-tech capital affects service flows.

Finally, an Aggregation "Paradox"

1. Two countries A and B.

2. Sectors 1 and 2 in each country. These sectors produce the same goods in each country.

3. Input growth same in both sectors in both countries $\Rightarrow$ TFP growth determined by output growth.

4. $Y_j^t =$ real value added in sector j for period t, $t = 0, 1$.

Consider:

$$\frac{Y_{A1}^1}{Y_{A1}^0} > \frac{Y_{B1}^1}{Y_{B1}^0},$$

and

$$\frac{Y_{A2}^1}{Y_{A2}^0} > \frac{Y_{B2}^1}{Y_{B2}^0}.$$

PARADOX *Although A has higher productivity growth in both sectors, it can have lower aggregate productivity growth than B. That is, the following is possible:*

$$\frac{Y_{A1}^1 + Y_{A2}^1}{Y_{A1}^0 + Y_{A2}^0} < \frac{Y_{B1}^1 + Y_{B2}^1}{Y_{B1}^0 + Y_{B2}^0}.$$

How is this possible?

$$\frac{Y_{A1}^1 + Y_{A2}^1}{Y_{A1}^0 + Y_{A2}^0} = \theta_{A1}^0 \cdot \frac{Y_{A1}^1}{Y_{A1}^0} + \theta_{A2}^0 \cdot \frac{Y_{A2}^1}{Y_{A2}^0},$$

where $\theta_{Aj}^0 = Y_{Aj}^0/(Y_{A1}^0 + Y_{A2}^0)$, $j = 1, 2$.

Sector shares play a role in determining aggregate productivity.

Useful to keep in mind when making international comparisons. Strong productivity growth in one industry (e.g. mining) may give a misleading picture of relative performance more broadly defined.

Conclusions

1. Difficult to know how much high-tech and public capital is "enough". Depends on purpose, consumption attributes and impacts on prices.

2. Underinvestment can be just as undesirable as overinvestment.

3. Evidence does not provide comprehensive cost-benefit analysis: social user cost versus social user benefit (Morrison and Schwartz, 1996).

4. Location matters of both types of capital matters, but little empirical evidence.

5. Quality matters, but difficult to measure.

6. Efficiency matters, but difficult to measure.

7. Disaggregate level of analysis seems preferable.

Some areas where progress seems possible:

1. Disaggregation of high-tech and public capital into components to allow investigation of productivity impacts. Some (e.g. schools) would be expected to have long-run impacts, some (e.g. roads) more immediate impacts.

2. Regional disaggregation:

   - Point versus network effects — some capital impacts on broader regions than others (roads and telecommunications infrastructure versus water works and PCs). (Boisso, Grosskopf and Hayes, 2000)

- Positive impacts on one region could lead to negative impacts on other regions. Opportunity costs of each investment option.

- Private-sector (and household) resource re-allocation caused by private and public infrastructure choices.

References

Aschauer, D.A. (1989a), "Is Public expenditure Productive?" *Journal of Monetary Economics* 23, 177–200.

Aschauer, D.A. (1989b), "Does Public Capital Crowd out Private Capital," *Journal of Monetary Economics* 24, 171–188.

Basu, S. and J. G. Fernald (1997), "Returns to Scale in U.S. Production: Estimates and Implications," *Journal of Political Economy* 105, 249-283.

Berndt, E.R. and B. Hansson (1991), "Measuring the Contribution of Public Infrastructure Capital in Sweden," NBER Working Paper No. 3842.

Boarnet, M. (1998), "Spillovers and the Location Effect of Public Infrastructure," *Journal of Regional Science* 38, 381–400.

Boisso, D., S. Grosskopf and K. Hayes (2000), "Productivity and Efficiency in the US: Effects of business cycles and public capital," *Regional Science and Urban Economics* 30, 663–681.

Connolly, E. and K.J. Fox (2006), "The Impact of High-Tech Capital on Productivity: Evidence from Australia," *Economic Inquiry* 44, 50–68.

Daveri, F. (2002), "The New Economy in Europe, 1992-2001," *Oxford Review of Economic Policy* 18(3), 345–362.

W.E. Diewert and K.J. Fox (2004), "Returns to Scale, Technical Progress and Monopolistic Markups," manuscript.

Fox, K.J. (1999) "Efficiency at Different Levels of Aggregation: Public vs. Private Sector Firms," *Economics Letters* 65, 173–176, 1999.

Fox, K.J. (2003), "Problems with (Dis)Aggregating Productivity, and Another Productivity Paradox," UNSW School of Economics Discussion Paper 2003/01.

Grimes, A. (2003), "Economic Growth and the Size and Structure of Government: Implications for New Zealand," *New Zealand Economic Papers* 37, 151-175.

Haughwout, A.F. (1998), "Aggregate Production Functions, Interregional Equilibrium, and the Measurement of Infrastructure Productivity," *Journal of Urban Economics* 44, 216–227.

Haughwout, A.F. (2002), "Public Infrastructure Investments, Productivity and Welfare in Fixed Geographic Areas," *Journal of Public Economics* 83, 405–428.

Hicks, J.R. (1935), "The Theory of Monopoly: A Survey," *Econometrica* 3, 1–20.

International Monetary Fund (2002), *Government Finance Statistics Yearbook*, Washington D.C.

Morrison, C.J. and A.E. Schwartz (1996), "State Infrastructure and Productive Performance," *American Economic Review* 86, 1095–1111.

Munell, A. (1990), "Why has Productivity Growth Declined? Productivity and Public Investment," *New England Economic Review*, January/February, 3–22.

Organisation for Economic Cooperation and Development (2003), Economic Outlook 72, Paris.

Otto, G. and G. Voss (1994), "Public Capital and Private Sector Productivity," *The Economic Record* 70, 121–132.

Otto, G. and G. Voss (1995), "Public Capital and Private Sector Productivity: A Review of the Empirical Evidence," *Economic and Labour Relations Review* 6, no. 1, 52-70.

Otto, G. and G. Voss (1996), "Public Capital and Private Production in Australia," *Southern Economic Journal* 62, no. 3, 723-38.

Otto, G. and G. Voss (1998), "Is Public Capital Provision Efficient?" *Journal of Monetary Economics* 42, no. 1, 47-66.