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Productivity and Economic Growth in Australia, New Zealand and Ireland

Dimitri Margaritis, Frank Scrimgeour, Michael Cameron, and John Tressler

It is generally accepted that productivity growth is a major source of economic growth and welfare improvement. Labour productivity has accounted for roughly half of the growth in per capita GDP in the OECD over the last two decades, with the other half primarily accounted for by increases in labour utilisation, that is, changes in the demographics, unemployment and labour force participation rates. For this reason, productivity is of vital interest to economists and policymakers. An understanding of technical and efficiency change, two key factors in productivity growth, is thus important in policy decision-making.

Academics and policy makers continue to debate the relative contributions of shocks and policy changes impacting on population growth, capital accumulation, microeconomic behaviour and technological advance. Different policy settings impact on both aggregate performance and the productivity of sectors and factors.

This paper presents an analysis of the relative growth performance of Australia, New Zealand and Ireland concentrating on the underlying components of labour productivity, particularly efficiency change and technical change. Such analysis is important to policy decisions of countries seeking to improve their relative international position and outlook. It is important that policymakers identify sustainable productivity changes (largely driven by technological change) separately from measured productivity change. This separation facilitates assessment of the extent to which technology adoption and diffusion contribute to a productivity catch-up.

This work is similar in many respects to recent studies undertaken by the OECD (2004a), but with important methodological differences introduced by Margaritis, Färe and Grosskopf (2005). The individual contributions of industry productivity growth and sectoral composition to aggregate productivity are also considered. The novelty of the productivity measurement and analysis used by Margaritis, Färe and Grosskopf is that it 'derives from a decomposition of the growth in labour productivity in terms of (a) technical change both neutral and biased, (b) efficiency change, and (c) capital accumulation'. Each component's contribution to the growth in labour productivity can then be assessed.

The paper proceeds as follows. We outline the relative economic growth performance of Australia, New Zealand and Ireland over the period 1979-2002,

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Dimitri Margaritis is Professor Faculty of Business, Auckland University of Technology. Frank Scrimgeour, Michael Cameron and John Tressler are respectively Professor, Doctoral Candidate and Associate Professor in the Department of Economics, University of Waikato.

summarise the key policy reforms in the three countries and the perceived drivers of productivity growth. We then briefly discuss the methodology and rationale for the particular productivity measure used in this paper. Productivity performance of the three countries over the period is reported, focussing on efficiency change, technical change, and capital accumulation movements. Technical change is further decomposed into input-biased technical change and a neutral component. We also investigate how trends in industry productivity affect aggregate productivity performance across the OECD countries. Finally we compare our results with other studies of productivity in the three countries and provide concluding remarks.

Economic Growth in Australia, New Zealand, and Ireland: 1979-2002

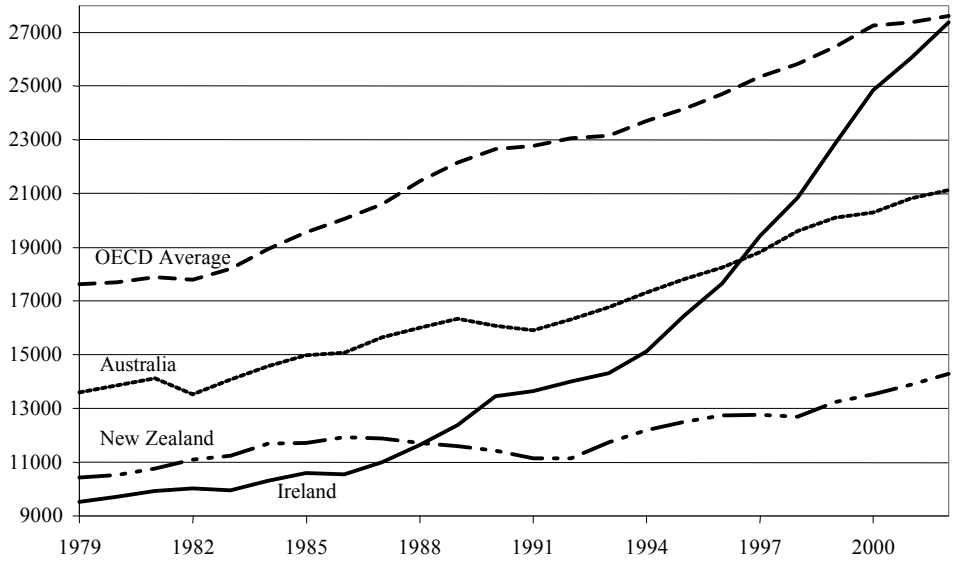
The different experience of the three countries over the last two decades is readily apparent when aggregate measures of per capita output are compared. Figure 1 illustrates the growth of real per capita Gross Domestic Product (GDP) for Australia, New Zealand, Ireland, and the OECD average, over the period from 1979 to 2002. In 1979, all three countries had real per capita GDP below the OECD average. It is obvious that Ireland has outperformed most OECD countries in terms of economic growth over the last decade. By 2001, Ireland had overtaken both New Zealand and Australia and had almost reached the OECD average, with most of the catch-up by Ireland occurring after 1990. Ireland's real per capita GDP grew on average by 2.7 per cent through the 1980s, but grew by 6.4 per cent on average through the 1990s, well ahead of the OECD average of 1.7 per cent over the same period. Australia also grew faster than the OECD average in the 1990s (2.1 per cent on average), while New Zealand fell further behind (1.4 per cent). This paper provides an explanation of the differences in the economic growth experience of the three countries.

Policy and Productivity

All three countries experienced a similar productivity slowdown during the 1970s. This period has been studied closely, and several explanations have emerged including (i) energy price shocks; (ii) inflation; (iii) changes in the composition of the labour force; (iv) increasingly regulated markets and unionisation; and (v) changes in the composition of output (Norsworthy, Harper and Kunze, 1979; Clark, 1982; Link, 1987). Energy price shocks in the 1970s encouraged diversion of investment away from increasing the capital stock, towards replacing existing energy-inefficient capital. Inflation both lowered the saving rate, and diverted investment from productive capital to the purchase of non-productive assets that would hold their value over time. The labour force grew quickly through this period, mainly due to increases in the youth and female labour force. Much of this new labour force was relatively lower-skilled, reducing the average productivity of the workforce. Government regulation such as environmental and work safety programs reduce measured productivity due to the compliance costs associated

with them. Unionisation reduces productivity by limiting the effectiveness of incentives such as performance-based pay schemes. Finally, as the composition of industries in the economy changed increasingly towards services, labour was diverted away from manufacturing and into service industries where productivity growth is slower.

Figure 1: Real per Capita GDP (1995 $US)



Source: World Bank Development Indicators, http://devdata.worldbank.org/dataonline/

The productivity slowdown experienced by Australia, New Zealand and Ireland, and the need to restructure and modernise, ultimately led to necessary microeconomic and macroeconomic policy reform. However, their approaches to reform were markedly different. Ireland's policy reform focused on encouraging foreign direct investment; New Zealand utilised extensive market-based policy reform; while Australia used a more measured approach concentrating on institution building.

The Irish government finally responded to the 1980s national fiscal crisis by initiating the Programme for National Recovery in 1987 — this program established an important sense of national purpose and direction for Ireland, in addition to fiscal restraint (O'Connell, 1999). One highly successful initiative was an amnesty for delinquent taxpayers. This resulted in a financial windfall of IR£500 million and set the stage for decreases in marginal tax rates through the 1990s. Low tax rates were used as an incentive for foreign high-technology firms to establish themselves in Ireland. The Irish government also deregulated several key industries, including telecommunications and the airline industry, which proved to be additional key factors in attracting foreign direct investment.

Further, a re-orientation of the state-funded tertiary education sector to focus on science and technology graduates, coupled with the abolition of tertiary education fees, saw a huge increase in the skill level of the labour force (Burnham, 2003).

In New Zealand, extensive policy reform followed the election of a new government in 1984. Wage, price, and interest rate controls were removed and the exchange rate was devalued, and then floated (Bollard, Lattimore and Silverstone, 1996). Tariffs were removed or reduced on most imported goods, and many production incentives and subsidies were withdrawn. This forced local industry to modernise in order to compete with cheaper imported goods. Inefficient state assets were first corporatised as State-Owned Enterprises. Some were later sold to private business interests in order to raise funds to reduce public debt (Chatterjee, 1996). A new fund for research and development (the Foundation for Research, Science and Development) was created, and government research bodies were corporatised (as Crown Research Institutes). The key mechanisms of monetary policy were changed, with a new focus on keeping inflation low and stable — this goal was not achieved until 1992, and the disinflation process involved significant economic cost to the country. The labour market was extensively deregulated, and in 1991 the Employment Contracts Act significantly reduced the bargaining power of trade unions (Bollard, Lattimore and Silverstone, 1996). These pro-market reforms were completed rapidly, and virtually all markets had experienced some reform by 1991.

Australia followed a similar path of macroeconomic and microeconomic reform to New Zealand. However, in comparison Australia employed a much more measured and cautious approach to reform, and reform in most markets occurred significantly after equivalent reform in New Zealand. Tariffs and agricultural subsidies were progressively removed from the 1970s through to the 1990s, and export controls on many natural resources such as coal and iron ore were relaxed or removed. Government Business Enterprises were reformed so that prices reflected actual costs, but privatisation did not occur to the same extent as in New Zealand. Company taxes were cut from 49 per cent to 39 per cent in 1987, then to 33 per cent in 1993. Greater flexibility and decentralisation of the wage setting mechanism was pursued in labour market reform — in 1996, the Victorian state government introduced individual and collective contracts, almost eight years after similar reform in New Zealand (Industry Commission, 1998).

The recent literature (see OECD, 2003 for a review) suggests that (i) macroeconomic stability; (ii) regulation; (iii) financial markets; (iv) education; and (v) research and development, are important drivers of labour productivity growth. Macroeconomic stability, including fiscal prudence and low inflation, is important for business and consumer confidence and promotes efficient resource allocation. The central banks of Australia, Ireland (currently part of ECB) and New Zealand all concentrate on maintaining low stable inflation while the respective governments maintain a reasonably balanced budget. But macroeconomic stability, however beneficial it might have been for enhancing the countries growth prospects, is a necessary but not a sufficient precondition for sustainable growth.

Business development and entrepreneurship are easily hampered by excessive regulation and administrative requirements, and by financial markets that concentrate investment on risk-averse activities. Streamlining the regulatory environment for new enterprises should have a positive effect on productivity growth, as should financial markets that provide venture capital for innovative activities in addition to financing established activities. Efficient markets for both inputs and output, characterised by increased competition, are also important. Flexible labour and input markets ensure that workers and resources will shift to the most productive (and rewarding) sectors, increasing productivity. The size of government is also thought to be important, with large tax burdens having a negative effect on output per capita and high government spending crowding out private investment due to increases in the real interest rate. Business tax burdens in both Australia and New Zealand are substantially higher than Ireland's.

Productivity growth is associated with greater specialisation of labour and capital, suggesting economies of scale are important in generating productivity growth. In small domestic markets such as New Zealand or Ireland, economies of scale in production must be generated through export promotion. Ireland, as part of the European Union and with a large United Kingdom market on its doorstep, seems particularly well placed to take advantage of economies of scale in production.

Human capital is already recognised as critically important in labour productivity. All three countries have promoted skills acquisition and re-training of the unemployed workforce, as well as increasing compulsory schooling. However, incentives for tertiary education have been quite different. While New Zealand and Australia maintain 'user-pays' education at tertiary level, Ireland abolished tertiary education fees in 1996 to broaden access to higher education for all socio-economic groups. However, since the abolition of tertiary fees occurred well after Ireland's high productivity growth had begun, it is unlikely to have made a significant contribution, but may have prolonged the period of high productivity growth by providing a highly-skilled, motivated, innovative and adaptable young workforce. Färe, Grosskopf and Margaritis (2005) estimate that about one fifth of Ireland's growth in labour productivity over 1965-1998 is due to human capital accumulation but this effect is likely to have been much more modest in recent years as a tight labour market has forced employers to hire low-skilled labour. The OECD (2004a) reports a very small contribution of human capital to labour productivity growth in Ireland (and Australia) with a slight negative contribution for New Zealand in 1990-2000.

Research and development, and in particular private sector research and development, is strongly linked to productivity growth. Research and development potentially increases productivity, either directly through innovation or through technology spill-overs. A decrease in R&D intensity may not affect steady-state GDP per capita but is likely to reduce technological progress (see OECD, 2004a). To promote private research and development, governments should concentrate on human capital development, promotion of venture capital markets, and intellectual property rights. While all three countries have similar

protection of intellectual property rights, incentives for research and development appear to be higher in Ireland: In 2002, private research and development accounted for 0.80 per cent of GDP in Ireland, compared with 0.73 per cent in Australia and just 0.43 per cent in New Zealand (OECD, 2004b).

Methodology and Data

In this paper, labour productivity is defined as output per labour hour worked. This is commonly accepted as a better measure of the labour input actually used in the production process than using the number of employed, and is therefore more appropriate for efficiency and productivity measurement. Since this paper concentrates on the efficiency and productivity sources of growth, the GDP per hours worked measure is used.

Care was taken to avoid measurement bias problems in the productivity index arising from restrictive assumptions about market structure or the type of technology in the measurement of technological change and diffusion. The increasingly volatile behaviour of productivity measures further complicated the task of disentangling permanent from temporary shifts in measured productivity. Margaritis, Färe and Grosskopf (2005) calculated multifactor productivity growth and its efficiency and technological change components for a sample of 19 OECD countries[1] over the period 1979 to 2002. In particular, the approach outlined below constructs an aggregate best practice frontier for the OECD region using data envelopment analysis (DEA) methods, and individual countries are compared to that frontier. Technical change is then defined as a shift in the production frontier between two time periods. Malmquist productivity indexes were also computed and decomposed into the underlying productivity components for each country. Rather than specifying and estimating a specific production function, the technologies were constructed non-parametrically using DEA (Margaritis, Färe and Grosskopf, 2005 provide a thorough discussion; for more detail on the Malmquist index, see Färe *et al*, 1994). Restrictive assumptions about market structure or optimising behaviour were not required other than minimal regularity conditions, and an assumption of constant returns to scale.

An important feature of the Malmquist (multifactor) productivity change index (MALM) is that it can be decomposed into an efficiency change component (ECH) and a technological change component (TCH). Furthermore, following Kumar and Russell (2002) we can decompose the change in labour productivity between two periods (YCH) into (i) an efficiency change; (ii) technological change; and (iii) change in the capital to labour ratio (KCH). It follows that:

$$\begin{aligned} YCH &= MALM \cdot KCH \\ &= ECH \cdot TCH \cdot KCH \end{aligned}$$

[1] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Portugal, Spain, Sweden, United Kingdom, and the United States of America.

Since constant returns to scale are assumed, only variation in capacity utilisation or differences in the structure of each country will affect efficiency. Further, in the absence of joint input and output neutrality, the technical change component can be decomposed into an output biased (OBTC), an input biased (IBTC), and a (net) magnitude component (MTC). Because there is only one output, OBTC is equal to one here. IBTC represents the component of technical change that relates to relative changes in the inputs giving rise to non-parallel shifts in the production frontier. MTC represents the residual (parallel) component of technical change. Summarising the relationships:

$$YCH = ECH \cdot IBTC \cdot MTC \cdot KCH$$

To assess how sectoral changes contribute to productivity growth we will use a shift-share analysis. This may demonstrate whether resources have been substantially reallocated from low to high productivity industries possibly as a result of structural policies; whether these changes have added to overall productivity; and which particular industries have made the greatest contribution to aggregate productivity growth. We divide aggregate labour productivity growth into three components: an intra-sectoral or 'within' sector component measuring the (counterfactual) contribution of each industry to aggregate productivity; a static 'in between' component measuring the effect of changes in industry employment shares on aggregate productivity; and a dynamic (interaction) component capturing the residual effect of changes in both industry productivity and employment shares. The shift-share analysis was carried out for the following ten industries[2]: agriculture, mining, manufacturing (low-tech), manufacturing (high-tech), utilities, construction, wholesale and retail trade, transport and communication, financial services, and general services (high-tech/high-skill).

This paper uses data on aggregate output (PPP-adjusted value-added real GDP) and employment (annual hours worked) from the Total Economy Database of Groningen University (www.ggdc.net), on PPP-adjusted real capital stock from the GGDC Total Economy Growth Accounting Database and the New Zealand Treasury, and industry output (value-added) and employment data from the GGDC's 60-industry database. The data for Australia and New Zealand are from Statistics New Zealand and Australian Bureau of Statistics databases.

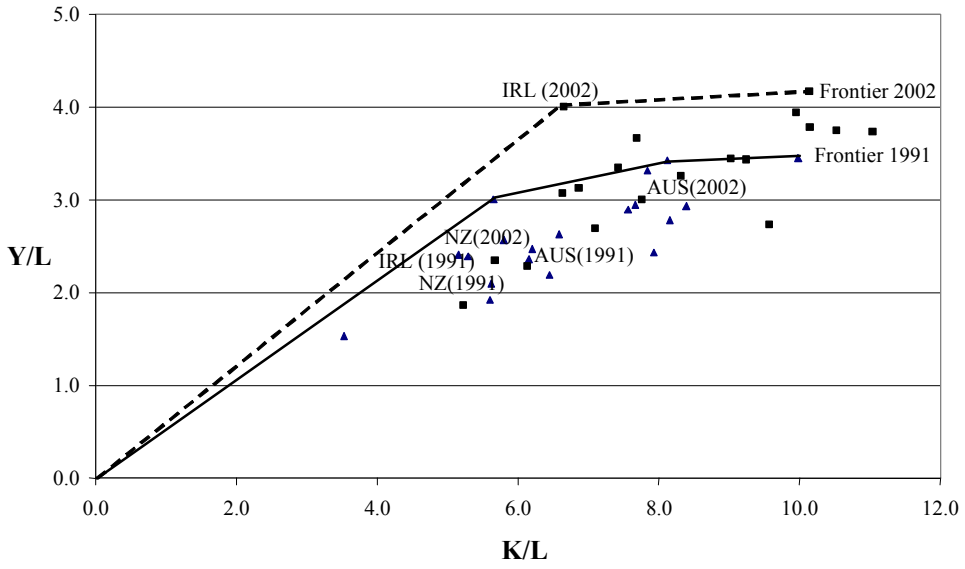
Review of Productivity Performance: 1979-2002

In Figure 2 the performance of individual countries is compared with the empirically constructed OECD production frontiers in 1991 and 2002. These frontiers are a benchmark derived from the best practice prevailing in the sample of 19 OECD countries, namely, USA, France and the Netherlands in 1991, and Ireland and France in 2002. The shift in the frontier between these two periods is clearly non-parallel indicating that technical change was non-neutral. It is evident

[2] For Australia, data constraints meant that only nine industries could be used: Manufacturing therefore includes both high-tech and low-tech industries.

from figure 2 that New Zealand is far from the efficient frontier, and has not closed the gap over that period. Australia was closer to the frontier in 1991 than New Zealand, but not significantly closer in 2002, and had a large increase in capital per labour hour over that period. Ireland was in a similar position to New Zealand in 1991, but by 2002 they had pushed the efficient frontier around the medium capital intensity region significantly outwards.

Figure 2: Production Frontiers 1991 and 2002



The difference in productivity improvements between the three countries is again demonstrated in Table 1. Output per labour unit in Ireland grew 158 per cent between 1979 and 2002, compared with 55 per cent for the OECD average, 44 per cent in Australia, and 20 per cent in New Zealand. This also shows New Zealand falling behind the OECD average over the period, with much lower growth in output per labour hour in both the 1980s and 1990s.

Table 1: Growth in Output per Labour Hour (Y/L)

	Y/L 1979	*Y/L 1991*	*% change 1979-1991*	*Y/L 2002*	*% change 1991-2002*	*% change 1979-2002*
Australia	2.08	2.36	13.5	3.01	27.4	44.6
Ireland	1.55	2.41	55.3	4.01	66.5	158.5
New Zealand	1.94	2.10	7.9	2.35	12.0	20.8
OECD Average	2.08	2.62	25.7	3.25	24.0	55.8

The three countries are also quite different in terms of capital depth (Table 2). New Zealand had slightly more capital per labour hour than the other two countries in 1979, but increases in capital were much lower in the 1980s, and negligible through the 1990s. Australia experienced capital deepening in line with the OECD sample average, while Ireland's capital stock (per labour hour) grew almost twice as fast as Australia's.

Table 2: Growth in Capital per Labour Hour (K/L), 1979-2002

	K/L 1979	*K/L 1991*	*% change 1979-1991*	*K/L 2002*	*% change 1991-2002*	*% change 1979-2002*
Australia	5.17	6.15	19.0	7.76	26.1	50.0
Ireland	3.36	5.15	53.5	6.65	29.0	98.0
New Zealand	5.22	5.62	7.8	5.67	0.9	8.7
OECD Average	5.59	6.72	20.1	8.16	21.5	45.9

Table 3 gives a summary description of the average multifactor productivity (MFP) performance of Australia, New Zealand, and Ireland, over the periods 1979 to 1991 and 1991 to 2002. The multifactor productivity estimates reported in Table 1 are relative productivity performance results derived from comparing each country against the benchmark production frontiers as presented in figure 2.

Table 3: Average Annual Multi-Factor Productivity Changes (%)

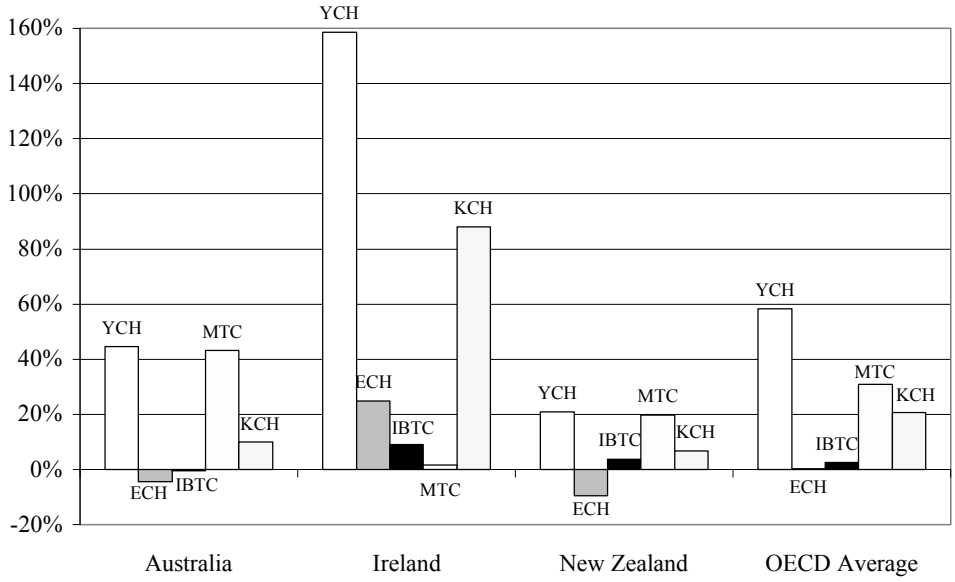
	1979-1989	1990-2002	1979-2002
Australia	0.87	1.74	1.25
Ireland	-0.44	2.65	1.46
New Zealand	0.35	0.82	0.56
OECD Average	1.33	1.17	1.26

In the 1980s, Australia out-performed both Ireland and New Zealand in multi-factor productivity growth, but Ireland performed much better in the 1990s. All three countries lost ground on the average of the 19 OECD countries sampled through the 1980s, where on average multi-factor productivity growth was 1.33 percent in the period 1979-1989 and 1.17 percent in the period 1990-2002. Both Ireland and Australia performed better than average through the 1990s, while New Zealand continued to under-perform relative to the average.

Labour productivity is decomposed into efficiency change (ECH), input-biased technical change (IBTC), a (net) magnitude technical change component (MTC), and capital deepening (KCH), in Figure 3. This decomposition is broadly consistent with what the raw data in Table 1 and Table 2 suggest, with Ireland exhibiting high capital growth and higher labour productivity gains, and New Zealand showing low capital growth and low productivity gains. Ireland's growth in labour productivity is clearly the highest of the three countries and well above

the OECD average. Multifactor productivity across the 19-country OECD sample is driven by (net) magnitude technological change and capital deepening, with negligible efficiency change. In contrast, New Zealand and Australia experienced negative efficiency change which offset the gains from capital deepening. Ireland also stands out due to large gains in capital intensity, considerable efficiency and (biased) technical change improvements.

Figure 3: Labour Productivity (YCH) Decompositions, 1979-2002



Sectoral Productivity

Shift-share analysis was used to gain further insights on the link between biased technical change and changes in sectoral composition. Shift-share analysis breaks down aggregate productivity growth into three components: an intersectoral or 'within' sector component which measures the (counterfactual) contribution of each industry to aggregate productivity growth; an 'in between' (static) component measuring the effect of changes in industry employment shares on aggregate productivity; and a dynamic (interaction) component which captures the residual effect of changes in both industry productivity and employment shares. These analyses indicate that industry contributions to aggregate labour productivity growth for the OECD countries are dominated by 'within' sector effects, with little contribution from sectoral shifts (the 'static' and 'dynamic' effects; data not shown). This suggests little impact on aggregate productivity growth from higher productivity industries gaining employment shares or lower productivity industries losing shares.

Table 4: Labour Productivity Decomposition Changes, Ireland

	1981 to 1990				*1991 to 2000*			
Sector	*Within*	*Static*	*Dynamic*	*Overall*	*Within*	*Static*	*Dynamic*	*Overall*
Agriculture, forestry	0.900	–0.185	–0.116	0.598	0.425	–0.817	–0.172	–0.564
Mining	0.031	–0.086	–0.017	–0.072	0.106	–0.051	–0.030	0.025
Manufacturing, low-tech	1.864	–0.299	–0.294	1.271	2.732	–0.781	–0.705	1.246
Manufacturing, high-tech	0.963	0.146	0.168	1.277	22.426	0.285	2.905	25.617
Utilities	0.107	–0.012	–0.008	0.087	0.398	–0.256	–0.217	–0.074
Construction	–0.331	–0.341	0.066	–0.606	0.499	0.469	0.206	1.175
Wholesale and retail trade	0.473	0.282	0.053	0.807	–0.101	0.389	–0.012	0.276
Transport and communication	–0.037	–0.046	0.001	–0.082	0.882	–0.081	–0.060	0.742
Financial services	–0.051	0.368	–0.022	0.295	0.887	0.187	0.123	1.197
General services	1.167	0.561	0.140	1.868	1.398	0.660	0.136	2.193
TOTAL	5.087	0.386	–0.029	5.444	29.652	0.006	2.175	31.833

Table 4 shows the shift-share analysis for the Irish economy over the period 1981-2000. The figures represent the contribution to economy-wide change in labour productivity of each sector, and the decomposition into 'within', 'static', and 'dynamic' effects. The analysis suggests that Ireland's strong productivity performance has been almost entirely driven by productivity gains in the high-tech manufacturing sector, which provided 23 per cent (that is,1.277 of 5.444) of the economy-wide change in labour productivity for the period 1981-1990, and over 80 per cent of the change in labour productivity for 1991-2000. Significant productivity gains have also been made in low-tech manufacturing, construction, financial services and general services. In all cases these productivity gains have been dominated by 'within' sector effects, rather than by re-distribution of employment to more productive uses. However, Ireland is unique in recording a sizable positive dynamic effect, consistent with an effective process of economic restructuring. This is particularly true of the high-tech manufacturing sector.

The highest contribution to labour productivity growth in New Zealand was made by the transport and communications sector, the financial services sector in the 1980s, and the utilities sector in the 1990s (see table 5). Productivity growth in the transport and communication and utilities sectors was driven by 'within' sector effects. In the financial services sector productivity growth is dominated by 'static' effects, suggesting changes in the share of employment in this sector was a significant driver of productivity growth. In contrast with Ireland, the contribution

of the high tech manufacturing and general services sectors to productivity growth has been much more modest.

Table 5: Labour Productivity Decomposition Changes, New Zealand

	1981 to 1990				*1991 to 2000*			
Sector	*Within*	*Static*	*Dynamic*	*Overall*	*Within*	*Static*	*Dynamic*	*Overall*
Agriculture, forestry	0.570	–0.118	–0.043	0.408	0.746	–0.521	–0.165	0.060
Mining	0.203	0.030	0.046	0.278	–0.027	0.014	–0.001	–0.015
Manufacturing, low-tech	0.672	–0.232	–0.047	0.392	0.494	–0.292	–0.039	0.164
Manufacturing, high-tech	0.697	–0.289	–0.117	0.290	0.140	–0.011	–0.001	0.128
Utilities	0.060	0.118	0.011	0.188	1.082	–0.541	–0.651	–0.110
Construction	0.470	–0.146	–0.062	0.262	–0.282	0.303	–0.072	–0.050
Wholesale and retail trade	–1.868	–0.050	0.015	–1.904	–0.184	0.693	–0.028	0.481
Transport and communication	1.290	–0.261	–0.209	0.820	2.186	–0.270	–0.233	1.684
Financial services	–0.036	1.598	–0.019	1.542	–0.476	0.782	–0.082	0.224
General services	0.029	0.168	0.004	0.201	0.297	0.052	0.010	0.359
TOTAL	2.086	0.817	–0.424	2.478	3.976	0.211	–1.262	2.925

Table 6: Labour Productivity Decomposition Changes, Australia

	1981 to 1990				*1991 to 2000*			
Sector	*Within*	*Static*	*Dynamic*	*Overall*	*Within*	*Static*	*Dynamic*	*Overall*
Agriculture, forestry	0.322	–0.253	–0.073	–0.004	0.313	–0.150	–0.038	0.124
Mining	0.601	–0.187	–0.113	0.301	0.666	–0.288	–0.135	0.242
Manufacturing	–0.189	–0.553	0.023	–0.719	0.466	–0.399	–0.049	0.018
Utilities	0.882	–0.377	–0.455	0.051	0.636	–0.350	–0.271	0.016
Construction	–0.440	0.339	–0.074	–0.175	0.094	0.290	0.015	0.399
Wholesale and retail trade	–0.528	0.249	–0.034	–0.313	1.113	–0.172	–0.055	0.886
Transport and communication	0.587	–0.356	–0.125	0.106	0.775	0.001	0.000	0.776
Financial services	–0.474	1.670	–0.220	0.977	0.116	1.176	0.029	1.321
General services	–0.411	0.355	–0.027	–0.083	0.580	0.028	0.003	0.611
TOTAL	0.350	0.888	–1.097	0.141	4.759	0.135	–0.501	4.393

Australia's productivity growth is dominated in both periods by the financial services sector. Similar to New Zealand, the static effect accounts for almost all productivity growth in this sector (see table 6). The transport and communication, and wholesale and retail trade sectors also contributed significantly to productivity growth in the 1990s, though dominated by 'within' sector effects. Manufacturing productivity growth in Australia was strongly negative in the 1980s and slightly positive in the 1990s, although both high- and low-tech manufacturing are included together, which may mask differences in the individual contributions of the high-tech and low-tech sectors.

Comparison with Other Selected Estimates

Cassidy (2004) reviewed aggregate and sectoral trends in Ireland's productivity performance, and found strong aggregate productivity growth, with an acceleration in the 1990s driven by the performance of high-technology sectors of the economy. He found that GDP per labour hour had increased on average by 3.6 per cent per annum over the period 1991-1995, and by 5.1 per cent per annum over the period 1996-2002. This corresponds to a 69 per cent increase in labour productivity over the twelve year period 1991-2002, which is similar to our estimate of 66.5 per cent for the same period. In decomposing productivity growth by sector, Cassidy attributed improvements in labour productivity over the period 1996-2000 to improvements in productivity within the manufacturing sector. This aligns well with our estimates that show productivity improvement in Ireland in the 1990s was dominated by the within sector effect of high-tech manufacturing.

Black, Guy and McLellan (2003) found an acceleration of multifactor productivity in New Zealand in the 1990s which is consistent with the results shown in Table 3. Gounder and Xayavong (2004) using a stochastic frontier production approach found that for the New Zealand manufacturing sector technical change increased in the post reform period (1984-1998), while efficiency declined. They also found that the deregulation period was associated with a decrease in allocative inefficiency which they attributed to a reduction in price distortions. These results are generally in line with those reported in Table 3 (for the whole New Zealand economy) and Table 5 (for the manufacturing industries) above. (Margaritis, Färe and Grosskopf (2005) report that IBTC in New Zealand was 0.32 per cent on average during 1990-2002 up from -0.01 per cent in the 1979-189 period. These improvements are likely to reflect the effect of better resource allocations (input mix) in response to relative changes in factor prices.)

Parham (2000) showed that Australia experienced acceleration in productivity growth in the 1990s which is consistent with the figures in Table 3. Parham (2004) estimated trend multifactor productivity for 12 industries, which showed multifactor productivity increases were greatest in the utilities and communications sectors through both the 1980s and 1990s. We found strong productivity growth in those sectors, but greater growth in the wholesale and retail trade and financial services sectors, both of which showed very little growth in the

estimates by Parham. Parham and Roberts (2004) decomposed labour productivity growth into multifactor productivity growth and capital deepening, and found capital deepening was a significant contributor to labour productivity growth, contributing around 60 per cent of labour productivity growth for New Zealand 1996-2002 and Australia 1979-2003. This is a significantly greater contribution than we report in our decomposition in Figure 3.

The actual multifactor productivity estimates from Parham (2004) and Parham and Roberts (2004) are probably not directly comparable to our estimates, not only because of the different time period but also because of the different methodology used. The multifactor productivity estimates reported in this paper are measures of relative performance when compared to the efficient frontier. They are derived from a Malmquist productivity index as opposed to the Tornqvist and Fisher indices used in the Black, Guy and McLellan (2003) paper; these indices can be shown to be equivalent to a Malmquist index provided that the technology can be modelled by specific parametric functional forms, for example, translog for Tornqvist; they also assume optimisation (for example, profit maximisation) behaviour and perfectly competitive markets, a situation which is not often the case in practice. In addition, conventional TFP measures assume that production takes place on the technology frontier, that is, there is no inefficiency. As it is seen in Figure 2 there is always a chance that countries (or their industries) will not operate at the frontier of technology; this distance, given by the proportionate increase in output for given inputs required to reach the frontier (or the proportionate reduction in inputs to produce a given level of output), is a measure of inefficiency.

Discussion

The growth experiences of Australia, New Zealand, and Ireland are a study in contrast, particularly through the 1990s. While Australia has performed generally in line with the OECD average, New Zealand has slowly fallen away, and Ireland has outperformed any other OECD country in terms of productivity growth. New Zealand is estimated to have one of the highest rates of multifactor productivity growth in the 1980s, while Ireland's growth rate is significantly higher than any other OECD country in the 1990s (about 4 per cent per annum, on average).

In Ireland, increases in productivity growth were driven predominantly by capital deepening, with a significant improvement in efficiency, while in New Zealand and Australia efficiency change was negative, and productivity growth was dominated by (neutral) technical change effects. It is somewhat surprising that New Zealand should experience efficiency losses despite undertaking perhaps the most extensive economic restructuring program in the OECD. This poor efficiency record explains in part New Zealand's continual fall away from the OECD average in aggregate production measures. New Zealand's productivity performance has also been hampered by slow growth in capital accumulation, particularly during the 1990s.

Obviously, different sources of productivity growth will be manifest in different measures of efficiency change and technical change. Labour shedding may lead to improvements in efficiency and therefore productivity provided that labour is not efficiently utilised (there is a slack) and shedding leads to higher rates of utilisation of the most efficient segment of the labour force. Better diffusion of technology and management practices will also lead to improvements in efficiency. In all these cases, efficiency improvements are captured by movements towards the frontier (best practice) of technology. The frontier itself can change over time; this is what we refer to as technological change. It results from the adoption of better technology practices. Shifts in the frontier do not have to be parallel (that is, technological change does not have to be neutral). This is illustrated in figure 2 where the shift in the frontier is clearly not proportional at different capital-labour ratios. What we observe in practice is that countries and industries change their input mix (and output mix in the case of more than one output); this can be the result of structural changes or other regulatory reforms that lead to changes in relative (input or output) prices. Input-biased technical progress may be the result of this; for example, widespread economic reforms in New Zealand may have led to positive IBTC growth (that is, change in relative input prices leading to a different, more optimal, input mix) and this performance may have been better than other countries given that the New Zealand reforms were phased in much earlier and were far more comprehensive than in other OECD countries. Recall that performance measures are relative. In Australia on the other hand, the reform process was a lot more gradual with most benefits realised well into the 1990s; this is consistent with the IBTC numbers reported in figure 3.

Sectoral shifts contribute surprisingly little to productivity growth, which is predominantly driven by within sector effects. Ireland is the exception, with strong 'in between' effects consistent with an effective process of economic restructuring. The high-tech manufacturing and tertiary sectors were the major contributors to productivity growth in Ireland. High-tech manufacturing had a much smaller effect in New Zealand and Australia, where tertiary sectors drove productivity growth.

Parham (2004) provides a good review of the literature on sources of productivity growth in Australia, suggesting that growth was driven by (i) accumulation of physical and human capital; (ii) greater openness of the economy to trade and investment; and (iii) increased research and development and the adoption of technology, particularly information and communication technology. Again our results corroborate these suggestions, as capital deepening proves a significant source of labour productivity growth.

By contrast, Cassidy (2004) suggested that the strong productivity growth of Ireland was largely driven by (i) substantial foreign direct investment (FDI), particularly from the United States; and (ii) considerable shifting of capital and labour from relatively low productivity sectors into high-tech sectors; and facilitated by (iii) a favourable exchange rate; (iv) increased integration with the European Union; and (v) the availability of a young, well-educated workforce. Our results corroborate these suggestions, and though the effect of input-biased

technical change is small in comparison to other effects, it is much larger than for Australia, New Zealand, or the OECD average. FDI inflows led to increasing capital deepening; adoption of better technology and diffusion (management practices); as well as facilitated 'dynamic' changes in sectoral productivity. All these appear to have been significant drivers of productivity growth in Ireland. In addition, the OECD (2004a) reports that Ireland's exposure to foreign trade (an indicator of export intensity and import penetration) increased in the 1990s; there was no change in the case of Australia; while New Zealand's exposure fell in the 1990s in comparison to the 1980s level. Given the discussion presented above it would appear that private research and development, innovation and technology spill-overs from the high-tech manufacturing sector have almost certainly driven the increases in productivity growth in Ireland. This was facilitated by significant foreign direct investment in this sector, particularly from the United States.

Conclusion

In this paper we investigated the growth experience of Australia, New Zealand, and Ireland over the period 1979-2002. Ireland has outperformed Australia and New Zealand, both in terms of economic growth, and labour productivity growth. In Ireland, increases in productivity growth were driven by both efficiency and technological change improvement and particularly by increases in labour productivity of the high-tech manufacturing and services sectors. Increases in labour productivity in the high-tech manufacturing sector in Ireland probably originated from research and development, innovation and technology spill-overs as a result of significant foreign direct investment.

Since productivity gains are realised at the firm level, it is difficult for policymakers to have a direct impact on productivity. However, productivity may potentially be improved by providing an economic policy environment with appropriate incentives for investment, entrepreneurship and innovation. This suggests a role for policymakers in addition to providing macroeconomic stability and encouraging human capital investment. Regulation of labour and financial markets also needs to be kept to a minimum to ensure a flexible supply of labour and financial capital is available.

Macroeconomic stability, appropriate regulation, efficient capital markets, higher education, and research and development are suggested to be important drivers of labour productivity growth. This is consistent with our findings. If Ireland is to be used as a model, our results suggest that policymakers should concentrate their efforts on providing an enabling economic environment that encourages investment (both foreign and domestic), entrepreneurship and innovation. This is in addition to existing goals of macroeconomic stability and human capital development.

References

Black, M., M. Guy and N. McLellan (2003), 'Productivity in New Zealand 1988 to 2002', New Zealand Treasury Working Paper 03/06, New Zealand Treasury, Wellington.

Bollard, A., R. Lattimore and B. Silverstone (1996), 'Introduction', pp. 1-30 in B. Silverstone, A. Bollard and R. Lattimore (eds), *A Study of Economic Reform — The Case of New Zealand,* Elsevier Science, Amsterdam.

Burnham, J. (2003), 'Why Ireland Boomed', *The Independent Review: A Journal of Political Economy* 7(4):537-556.

Cassidy, M. (2004), 'Productivity in Ireland: Trends and Issues', *Central Bank and Financial Services Authority of Ireland Quarterly Bulletin* Spring:83-105.

Clark, P. (1982), 'Inflation and the Productivity Decline', *American Economic Review* 72(2):149-154.

Färe, R., S. Grosskopf and D. Margaritis (2005), 'Productivity Growth and Convergence in the European Union', *Journal of Productivity Analysis* 25:forthcoming.

Färe, R., S. Grosskopf, M. Norris and Z. Zhang. (1994), 'Productivity Growth, Technical Progress, and Efficiency Change in Industrialized Countries' *American Economic Review* 84(1):66-83.

Gounder, R. and V. Xayavong (2004), 'A Decomposition of Total Factor Productivity Growth in New Zealand's Manufacturing Industries: A Stochastic Frontier Approach', presented to the New Zealand Association of Economists Conference, Wellington, 30 June-2 July.

Industry Commission, (1998), *Microeconomic Reforms in Australia: A Compendium from the 1970s to 1997*, Canberra.

Kumar, S. and R. Russell (2002), 'Technological Change, Technological Catch-up, and Capital Deepening: Relative Contributions to Growth and Convergence', *American Economic Review* 92(3):527-548.

Link, A. (1987), *Technological Change and Productivity Growth,* Harwood Academic Publishers, New York.

Margaritis, D., R. Färe and S. Grosskopf (2005), 'Productivity, Convergence and Policy: A Study of OECD Countries and Industries', *Journal of Productivity Analysis* forthcoming.

Norsworthy, J., M. Harper, and K. Kunze (1979), 'The Slowdown in Productivity Growth: Analysis of Some Contributing Factors', *Brookings Papers on Economic Activity* 2:387-421.

O'Connell, P. (1999), *Astonishing Success: Economic Growth and the Labour Market in Ireland,* International Labour Organization, Geneva.

OECD (2003), *The Sources of Economic Growth in OECD Countries*, Paris.

OECD (2004a), *Understanding Economic Growth,* Paris.

OECD (2004b), *OECD in Figures, 2004 edition*, Paris.

Parham, D. (2000), 'A More Productive Australian Economy', *Agenda* 7(1):3-16.

Parham, D. (2004), 'Sources of Australia's Productivity Revival', *The Economic Record* 80(249):239-257.

Parham, D. and P. Roberts (2004), 'Productivity Growth and Its Sources: How do New Zealand and Australia Compare?', presented to 'Productivity: Performance, Prospects and Policies' Workshop, Wellington, 28-29 July.

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