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INFORMATION AND COMMUNICATION TECHNOLOGY AND NEW ZEALAND'S PRODUCTIVITY MALAISE: AN INDUSTRY-LEVEL STUDY

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ABSTRACT

This paper examines the link between information and communication technology (ICT) and New Zealand's labour productivity (LP) growth in 29 industries over the period 1988-2003, and over relevant sub-periods. After deriving an ICT intensity index in order to classify industries into 'more ICT intensive' and 'less ICT intensive', we compare LP growth rates for these two industry groupings. Further, we employ dummy variable regression models, including difference-in-difference models, to more formally test the relationship between ICT intensity and LP growth. The results prove to be sensitive to the time period specified. When breaks in the data series are taken into account, there seems to be support for the view that LP growth of more ICT intensive industries has improved over time relative to that of less ICT intensive industries, even though overall LP growth was weak. To put it differently, the restrained New Zealand LP performance apparent from our data seems to have been due mainly to the decline in LP growth of less ICT intensive industries. Our results illustrate that lack of overall productivity growth per se is not necessarily evidence against the beneficial productivity impacts of ICT. Rather, the proper comparison is that between the productivity performance of more ICT intensive versus less ICT intensive industries. However, our results can only be taken as suggestive, given the fact that ICT is but one of the determinants of LP, and given the many inherent measurement problems.

Key Words: Information and Communication Technology, Labour Productivity Growth, ICT Intensive Industries, New Zealand.

JEL classification: O47, O50

1. INTRODUCTION

The OECD has emphasized that information and communication technology (ICT) has been, and remains to be, an important driver of growth and productivity in its member countries (OECD, 2003a). Recent improvements in growth and productivity performance in the US and many other OECD countries have been linked to the expansion of the production of ICT goods and the use of ICT to enhance efficiency and innovation (ibid.). A series of reports by the Australian National Office for the Information Economy (NOIE) also indicated that many industries in Australia seem to have gained substantial productivity benefits from the use of ICT.[1] New Zealand (NZ) is in the leading group of countries as measured by ICT uptake indicators (OECD, 2003a, p. 10).[2] Moreover, its reforms and policy changes implemented in order to stimulate the development of a knowledge-based economy seem to be heading in the right direction (Frederick and McIlroy, 1999). Indeed, NZ's recent rate of economic growth has remained strong despite a worldwide downturn starting in early 2001 (Shapiro, 2003).[3]

However, there are concerns about NZ's productivity performance. Scarpetta et al. (2000, p. 15) and OECD (2003b, p. 138) reported that NZ's productivity growth has been among the lowest in the OECD during the past two decades. Bar-Shira et al. (2003), comparing the productivity performance of the 25 richest economies, ranked NZ at the bottom of that group in 1990. Despite a number of NZ studies indicating that productivity growth improved from 1993 (Razzak, 2003; Black et al., 2003a), Shapiro (2003) argued that it has not accelerated after 1995. Färe et al. (2003) and OECD (2004) also concluded that so far the productivity improvements have not been sufficient to generate the conditions for stronger trend growth in GDP that would lift NZ back into the top half of the OECD, the stated goal of government policy.

Has something gone wrong? Have the economic reforms launched in 1984 failed? There are a large number of studies that have attempted to provide answers to these questions, but most of them had little to say about the contribution of ICT.[4] This paper attempts to fill this gap by examining the impact of ICT on NZ's productivity performance for the period 1988-2003. Following Stiroh (2002a), our analysis focuses on labour productivity (LP) growth of industries that are classified as either more ICT intensive or less ICT intensive (compared to the average ICT intensity across all industries).[5] We find that LP growth of more ICT intensive industries has improved over time relative to that of less ICT intensive industries, but that overall, LP growth was weak. To put it differently, the restrained NZ LP performance seems to have been due to the decline in LP growth of less ICT intensive industries. This is similar to Ark et al.'s (2002) findings for the EU in their comparison of US and EU productivity growth of ICT and non-ICT industries between the first and second half of the 1990s.

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1 See, e.g., NOIE (2004). Other relevant Australian studies, using different methodologies, include Parham et al. (2001) and Simon and Wardrop (2002).

2 ICT investment, however, has nevertheless been reported as being relatively low in NZ, mainly due to modest expenditure on software (OECD, 2004, p. 34/5).

3 It should be noted that recent economic growth in NZ was mainly driven by rapid population growth due to net migration and also by the strength of improving terms of trade (see, e.g., Galt, 2000, IMF, 2003).

4 See, e.g., Galt's (2000) review of the NZ growth and productivity literature and the NZ Treasury's (2004) recent stocktaking of its work on the country's growth performance and associated policy issues. The latter mentioned ICT in one short paragraph (ibid, p. 62).

5 A number of studies of the impact of ICT have similarly focused on LP as a way of circumventing the need for estimating ICT capital stocks at the industry level (Ark, 2002, p. 6).

Section 2 of the paper introduces the regression models used to assess the impact of ICT on LP growth. The selection of variables and data used to estimate LP is also discussed. Section 3 discusses the methodology employed to determine the ICT intensity of the 29 industries included in the analysis. Section 4 presents our empirical findings with regard to (1) the measurement of industries' ICT intensity, (2) LP growth rates for more ICT intensive versus less ICT intensive industries (for the entire 1988-2003 period as well as for relevant sub-periods), and (3) estimates of our regression models. This is followed by a concluding section (section 5) and two data appendices.

2. THE IMPACT OF ICT ON LABOUR PRODUCTIVITY GROWTH: DUMMY VARIABLE REGRESSION MODELS AND DATA

According to Schreyer (2000, pp.6-8), ICT can contribute to productivity growth through three channels. First, technological progress in the production of ICT goods directly raises total factor productivity (TFP) of ICT-producing industries. Secondly, falling prices of ICT capital relative to other types of capital or labour encourage firms to substitute the former for the latter. In this way, an increase in investment in ICT capital could contribute to LP growth in ICT-using industries through capital deepening effects, i.e. more capital per worker leads to an increase in LP. Thirdly, ICT could generate beneficial externalities, for example by improving business-to-business transactions through the Internet (i.e. businesses may gain benefits from cost savings through Internet transactions). Some authors also suggest that ICT could generate externalities in the form of production spillovers through efficiency gains in the production process, and through the accumulation of intangible organisational capital accompanying investment in ICT capital (Stiroh, 2002b; Basu et al., 2003). Such positive externalities, or spillover effects, can accelerate TFP growth in ICT-using industries.

Various studies have employed the standard neoclassical model to estimate the contribution of ICT to productivity growth.[6] They include ICT capital as an explanatory variable in either the growth accounting or regression framework. However, Stiroh (2002b, pp. 42-46) has highlighted that if, as is likely, the neoclassical assumptions do not hold and there are, for example, production spillovers, these models provide poor estimates of the true relationship between ICT and productivity growth. Moreover, there may be problems due to omitted variables, the presence of embodied technological change, measurement error or reverse causality, all of which could introduce a positive link between ICT intensity and TFP growth which should be absent in a neoclassical world.

[6] See, e.g., Schreyer (2000) and the survey by Daveri (2003).

To avoid such problems, Stiroh (2002a,b) and Ark et al. (2002) calculated industry productivity growth rates and employed dummy variable regression models, including difference-in-difference models. ICT capital was not included as an explicit variable. Instead, they sought to explain variations in either LP growth or TFP growth across more ICT producing, (more intensively) ICT using and other industries (i.e. less intensively ICT using industries, or 'non-ICT' industries).

In this paper, we employ a similar methodology to that used by Stiroh (2002a). However, due to the relatively high level of aggregation of our industry data it was not possible to have separate ICT producing and ICT using industries. Therefore, in this paper the term 'more ICT intensive industries' covers both more intensively ICT using industries as well as ICT producing industries, though the former make up the majority of more ICT intensive industries.[7] The remaining industries are classified as 'less ICT intensive industries'. Stiroh (2002a) in fact starts with the same approach as that adopted here, but was then able to drop ICT producing industries as part of his sensitivity analysis. In the case of NZ, the ICT producing sectors are less important compared to the US. However, as part of our sensitivity analysis we drop industries that contain ICT producing components, i.e. this is less precise compared to what Stiroh and Ark et al. did, but nevertheless enables us to obtain results that are clearly not mainly due to the influence of ICT producing sub-sectors.

Having calculated an 'ICT intensity index' (see section 3), we divide industries into more ICT intensive and less ICT intensive. We first calculate LP growth rates for each industry and also for the two aggregate industry groups. We then estimate three regression models based on dummy variable tests: Model (1) is used to analyse the growth rate of LP pre-1993 and post-1992[8]; Model (2) is used to distinguish the growth rate of LP between more ICT intensive and less ICT intensive industries; and Model (3) is used to test the effect of ICT on LP growth for the two types of industries pre-1993 and post-1992. The details of the models are as follows:

$$d\ln LP_{i,t} = \alpha_0 + \alpha_1 D + \varepsilon_{i,t} \quad (1)$$

$$d\ln LP_{i,t} = \beta_0 + \beta_1 ICT + \varepsilon_{i,t} \quad (2)$$

$$d\ln LP_{i,t} = \delta_0 + \delta_1 D + \delta_2 ICT + \delta_3 D \cdot ICT + \varepsilon_{i,t} \quad (3)$$

[7] Ark et al. (2002) found for their sample of 16 OECD countries that the key productivity differences between Europe and the US were in intensive ICT (using and producing) services, not ICT goods producing industries. NZ was not included in their sample of countries.

[8] Razzak (2003) also emphasized the importance of accounting for structural breaks in the data when estimating NZ productivity. He found a break point in 1992/93 in the GDP per working-age population data. We used a Chow test to test for breakpoints in our LP growth rate constructed from quarterly GDP data covering the period 1987:Q2 to 2003:Q2, and found one in 1993:Q3. We therefore report our estimates not only for the whole period covered by our data, but also for the sub-periods 1988-1992 and 1993-2003, in order to determine whether there was a change in LP growth after the break point. It seems to be generally recognized that NZ's growth performance improved markedly from around 1993 (see, e.g., The Treasury, 2004).

Where i=1,…,29 indexes the 29 industries, and t=1,…,15, indexes the annual observations over the period 1988-2003 (see Appendix A for further details). The variables and parameters are:

$d \ln LP_{i,t}$	Annual growth rate of labour productivity (LP) of industry i.
D	Dummy variable equals 1 if t ≥ 1993 and D=0 otherwise.
ICT	Dummy variable equals 1 if the industry is more ICT intensive and 0 otherwise.
α_0	Mean growth rate of LP, pre-1993.
$\alpha_0+\alpha_1$	Mean growth rate of LP, post-1992.
α_1	Change in mean growth rate of LP post-1992.
β_0	Mean growth rate of LP for less ICT intensive industries, 1988-2003.
$\beta_0+\beta_1$	Mean growth rate of LP for more ICT intensive industries, 1988-2003.
β_1	Change in mean growth rate of LP for more ICT intensive industries, 1988-2003.
δ_0	Mean growth rate of LP for less ICT intensive industries, pre-1993.
$\delta_0+\delta_1$	Mean growth rate of LP for less ICT intensive industries, post-1992.
δ_1	Acceleration of the LP growth rate for less ICT intensive industries, post-1992.
$\delta_0+\delta_2$	Mean growth rate of LP for more ICT intensive industries, pre-1993.
$\delta_1+\delta_3$	Acceleration of the LP growth rate for more ICT intensive industries, post-1992.
$\delta_0+\delta_2+\delta_1+\delta_3$	Mean growth rate of LP for more ICT intensive industries, post-1992.
δ_3	Differential acceleration (i.e. difference-in-difference) of the LP growth rate for more ICT intensive industries relative to others.
$\varepsilon_{i,t}$	Random error term.

Like Stiroh (2002a) we defined LP as real output per full time equivalent (FTE) employee.[9] In principle, LP measurement can be based on either gross output or value added data. We mostly used LP measured with gross output data following the arguments raised by Stiroh (ibid., p. 1562) that use of value added data leads to biased estimates and incorrect inferences about production parameters. However, we also calculated value added based LP as part of our sensitivity analysis in order to make our estimates more comparable with those reported in some other studies.

[9] Hours worked is usually the preferred measure of labour input, especially in cross-country comparisons, as it is a better proxy for workers' effort in the production process (Ahmad et al., 2003). However, due to lack of two-digit industry level hours worked data, the number of FTE employees were used instead.

To form LP growth series for the 29 two-digit industries covering the period 1988 to 2003, data were needed on real industry gross outputs and FTE employment. Most of the data used in this study were sourced from Statistics New Zealand.[10] Data on nominal gross outputs were primarily drawn from a recently upgraded set of production accounts based on System of National Accounts 1993 (SNA 93) accounting standards, which introduced new methods, such as the chain-linking of constant price GDP series, incorporated new source data and methods, and introduced industry categories in accordance with the Australian New Zealand Standard Industrial Classification (ANZSIC). Although a large number of changes have been made to the production accounts, the total effect on both the levels and patterns of annual changes of key measures such as GDP has, arguably, not been overly significant (Statistics New Zealand, 2000).

Production data were available for the period 1988 to 1999. Those for the period 2000 to 2003 had to be constructed. Industry real gross outputs were constructed using industry implicit price deflators, nominal intermediate consumption and value added. Data on FTE employment for 1997 to 2003 based on ANZSIC industry categories were drawn from Business Demography (BUD) Statistics. Industry FTE employment data from 1988 to 1996 according to the old NZIC industries were adjusted to the ANZSIC categories. See Appendix A for further information on data construction.

3. THE 'ICT INTENSITY INDEX'

The accuracy of the results reported in this study depends, among other things, on appropriately distinguishing more ICT intensive from less ICT intensive industries. Stiroh (2002a) used ICT's share of capital services in 1995 as the criterion, with industries above the mean value of this variable classified as 'IT-intensive industries'. Faced with a lack of appropriate European industry-level data on ICT capital stocks, Ark et al. (2002), while introducing some modifications, adopted a similar industry classification to that developed by Stiroh (2002a). In this paper, we have developed a NZ specific framework to obtain proxy measures of industries' ICT intensity, as ICT capital stock data were not available.

To measure the ICT intensity of industries we calculated the direct requirements of ICT inputs for each industry, using data for 126 four-digit level industries from NZ's 1996 Input-Output Table. The definition of the ICT sector used in this study is that of the OECD (see, e.g., OECD, 2002, Table A1, p. 83). It is "a combination of manufacturing and services industries that capture, transmit and display data and information electronically" (ibid., p. 81). In terms of ANZSIC, it includes the 17 four digit industries shown in Appendix Table B.2.

[10] Steve White of Statistics New Zealand kindly provided Excel files containing the national accounts data.

It was assumed that each industry can purchase ICT goods and services inputs from domestic producers and/or import them. Table 1 indicates the structure of intermediate input flows of our 29 industries. The matrices denoted ICT and X, respectively, represent the direct intermediate input requirements in terms of ICT and non-ICT commodities from domestic production. The matrices denoted ICT* and X* represent the direct intermediate input requirements of ICT and non-ICT commodities from imports.

Based on the structure of intermediate input flows, the sum of all direct intermediate inputs used by industry *j* (T_j) can be expressed as follows:

$$T_j = \sum_{i=1}^{J} x_{ij} + \sum_{l=1}^{L} ict_{lj} + \sum_{p=1}^{P} x^*_{pj} + \sum_{k=1}^{K} ict^*_{kj} \qquad (4)$$

Where *x, ict, x*,* and *ict** represent the elements of the matrices defined in Table 1, and *i,j*=1,…,29 indexes the 29 industries, k=1,…,5 indexes the five imported ICT commodities, l=1,…,6 indexes the (domestic) ICT-producing industries, and p=1,…,166 indexes the 166 imported non-ICT commodities (see Appendix Tables B.2 and B.3 for details of our lists of ICT-producing industries and imported ICT and non-ICT commodities).

Table 1: Intermediate Input Requirements Matrices

Intermediate input requirements	**Domestic production**	**X** is the 29 industry by 29 industry matrix of direct requirements of the domestic non-ICT input *i* per unit of output of industry *j*
		ICT is the 1 industry by 29 industry matrix of direct requirements of the domestic ICT input *l* per unit of output of industry *j*
	Imports	**X*** is the 166 commodity by 29 industry matrix of direct requirements of the imported non-ICT input *p* per unit of output of industry *j*
		ICT* is the 5 commodity by 29 industry matrix of direct requirements of the imported ICT input *k* per unit of output of industry *j*

Industry *j*'s ICT intensity index (I_j) was defined as direct ICT inputs to total inputs. It can be expressed as follows:

$$I_j = \left(\frac{\sum_{k=1}^{K} ict_{kj}^{*}}{T_j} \right) + \left(\frac{\sum_{l=1}^{L} ict_{lj}}{T_j} \right) \qquad (5)$$

The first term on the right-hand side of equation (5) is the share of imported intermediate ICT inputs in total intermediate inputs of industry j; the second term is the share of domestically produced intermediate ICT inputs in total intermediate inputs of industry j.

The ICT intensity indices were calculated in two steps, using the aggregation and disaggregation techniques for input-output tables described in United Nations (1999, pp. 218-225). The first step was to derive the elements of matrices X and ICT. We aggregated the 1996 inter-industry transaction table of 126 industries (at the four-digit level) into 29 industries (at the two-digit level). Since six of the newly aggregated industries contained the 17 sub-groups of ICT-related industries classified at the four-digit level, we netted them out to form the ICT-producing industry group. The employment shares of the 17 four-digit level ICT-related industries were used for this, as the preferred measure of gross output at basic prices was not available. See again Appendix Table B.2 for the list of ICT-related industries and their employment shares at the two digit-level. The second step was to derive the elements of matrices X* and ICT*. We aggregated the 1996 171 commodity by 126 industry import matrix into a 171 commodity by 29 industry matrix. We then divided the 171 commodities into two groups: ICT and non-ICT commodities (see Appendix Table B.3).

It should be noted that adoption of the particular ICT intensity index described in this section was largely driven by data availability, i.e. we expect the index to be improved upon in future should ICT capital stock data become available. Never-the-less, our classification of industries into more ICT intensive and less ICT intensive is similar to those currently used by other authors, although with some NZ specific features (see section 4.1).

4. EMPIRICAL RESULTS

4.1 Classifying Industries by ICT Intensity

Table 2 reports our classification of industries into more ICT intensive and less ICT intensive, plus the industry-specific values of our ICT intensity index this is based on. Like Stiroh (2002a), we used the median of the index as the criterion to divide industries into the two categories. If an industry's percentage of intermediate ICT inputs was greater than the median for all industries, i.e. 4%, it was classified as more ICT intensive (and vice versa for less ICT intensive industries). This classification is referred to below as 'industry classification A'.

The last three columns in Table 2 indicate that our classification is broadly in line with those of Stiroh (2002a) and Ark et al. (2002). The latter differ from Stiroh's and our approach to the extent that they decided to reclassify a number of more ICT intensive services sectors as belonging to the less ICT intensive group because "they use relatively little capital anyway as value added largely consists of labor income" (ibid., p. 8). Ark et al. (2002) argued that this does not affect their main results.

All industries in the primary sector (industries 1-4) were initially classified as less ICT intensive, whereas most of those in the services sector (industries 16-29) were classified as more ICT intensive (except for the "Accommodation, Cafés and Restaurants" and "Property Services" industries). It is not surprising that "Communication Services" stands out as having the highest ICT intensity of any industry, ranking first both in the proportion of intermediate ICT inputs from domestic production and from imports.[11] Amongst manufacturing industries, "Printing, Publishing and Recorded Media" and "Machinery and Equipment Manufacturing" are clearly more ICT intensive.

It should be noted that the shares of ICT inputs for "Agriculture", "Textiles and Apparel Manufacturing" and "Furniture and Other Manufacturing" are slightly below the median. Stiroh (2002a) and Ark et al. (2002) classified parts of the last two industries as ICT intensive and agriculture is known to be more R&D and technology intensive in NZ compared to other OECD countries.[12] To see how these three industries might impact on our results, we alternatively excluded and included them in the more ICT intensive group as part of our robustness analysis reported in sections 4.2 and 4.3. When they are included, the industry classification is referred to below as 'industry classification B'.

[11] Its expenses on imported inputs are related to payments for international communication services, including *inter alia* telecommunication, network and management services; hiring communications hardware and satellite equipments, etc. (see, e.g., Australian Bureau of Statistics, 1996, Division 75).

[12] Ministry of Economic Development (2003).

Table 2: ICT Intensity of Industries

	Industry	ICT Intensity Index			Is the industry more or less ICT intensive?*		
		$\frac{\sum_{k=1}^{5} ict_{kj}^{*}}{T_j}$	$\frac{\sum_{l=1}^{17} ict_{lj}}{T_j}$	I_j	This study	Stiroh (2002a)	Ark et al. (2002)
1	Agriculture	0.0%	3.9%	3.9%	No	No	No
2	Fishing	0.0%	3.1%	3.1%	No	No	No
3	Forestry and Logging	0.0%	3.6%	3.6%	No	No	No
4	Mining and Quarrying	0.1%	2.9%	3.0%	No	No	No
5	Food, Beverage and Tobacco Manufacturing	0.3%	1.8%	2.0%	No	No/Yes	No
6	Textiles and Apparel Manufacturing	0.5%	3.5%	4.0%	No	No/Yes	No/Yes
7	Wood and Paper Products Manufacturing	0.1%	2.3%	2.4%	No	No	No
8	Printing, Publishing and Recorded Media	0.5%	4.1%	4.6%	Yes	Yes	Yes
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	0.3%	3.0%	3.3%	No	No	No
10	Non-Metallic Mineral Products Manufacturing	0.1%	3.0%	3.1%	No	No	No
11	Metal Product Manufacturing	0.1%	3.3%	3.4%	No	No	No
12	Machinery and Equipment Manufacturing	0.8%	4.5%	5.3%	Yes	Yes	Yes
13	Furniture and Other Manufacturing	0.4%	3.4%	3.9%	No	No/Yes	No/Yes
14	Electricity, Gas and Water Supply	0.0%	2.2%	2.2%	No	No	No
15	Construction	0.1%	2.9%	3.0%	No	No	No
16	Wholesale Trade	0.8%	5.8%	6.6%	Yes	Yes	Yes
17	Retail Trade (including motor vehicle repairs)	0.0%	5.0%	5.1%	Yes	Yes	Yes
18	Accommodation, Cafes and Restaurants	0.0%	3.0%	3.0%	No	No	No
19	Transport and Storage	0.1%	6.2%	6.4%	Yes	No/Yes	No
20	Communication Services	14.5%	14.0%	28.6%	Yes	Yes	Yes
21	Finance, Insurance	0.2%	6.0%	6.2%	Yes	Yes	Yes
22	Property Services	0.0%	1.7%	1.7%	No	No	No
23	Ownership of Owner Occupied Dwellings	0.2%	4.0%	4.2%	Yes	Yes	Yes
24	Business Services	2.0%	7.9%	9.9%	Yes	Yes	No/Yes
25	Government	0.8%	7.1%	7.9%	Yes	n.a	No
26	Education	0.3%	6.1%	6.4%	Yes	Yes	No
27	Health and Community Services	0.0%	5.1%	5.1%	Yes	Yes	No
28	Cultural and Recreational Services	3.3%	8.0%	11.3%	Yes	n.a	No
29	Personal and Other Community Services	0.0%	6.1%	6.1%	Yes	n.a	No
	Median	0.1%	3.9%	4.0%			

Notes: In the last two columns, a No/Yes means that parts of the industry were classified as, respectively, less ICT intensive and more ICT intensive. See Ark (2002, p. 45, Appendix Table A1) for a more disaggregated comparison of theirs and Stiroh's ICT intensity classification. *We classify an industry as more ICT intensive if the value of its ICT Intensity Index is greater than 4%.

4.2 Labour Productivity Growth Rates of More ICT Intensive Versus Less ICT Intensive Industries

4.2.1 Main Results

Table 3 provides a summary description of the LP performance of each industry over the period 1988 to 2003 as well as over the sub-periods 1988-92 and 1993-03. Figure 1 shows the movement of LP for individual industries over time. The wide disparities in LP growth rates between industries are striking.[13] Overall, more than two-thirds of industries had positive LP growth over the whole period (1988-03) and the 1993-03 sub-period (during 1988-92, 17 industries had positive LP growth) (see LP columns 1-3, Table 3). However, there was no acceleration of LP growth from the first to the second sub-period. Rather, there has been a *deceleration* on average, and also for just over half of the 29 industries (see the column labeled 'acceleration' in Table 3).

In the primary sector, all four industries had positive LP growth over the whole 1988-03 period, but this masked the fact that two industries had falling LP growth over the 1993-03 sub-period, and only one industry showed an acceleration of LP growth from the first to the second sub-period (i.e. "Mining and Quarrying"). In the manufacturing sector, LP growth improved the most in the two more ICT intensive industries "Machinery and Equipment Manufacturing" and "Printing, Publishing and Recorded Media". The majority of less ICT intensive manufacturing industries (5 out of 7) had a deceleration in LP growth, although all but one of the less ICT intensive manufacturing industries had higher annual LP growth rates than the more ICT intensive manufacturing industries during the 1988-03 period.

As the majority of industries in the manufacturing sector, and all of those in the primary sector, are classified as less ICT intensive (industry classification A), the decline of the overall mean LP growth rate between 1988-92 and 1993-03, i.e. from 1.92 to 1.3, can be attributed to these industries. This is illustrated by the change in mean LP growth for the two categories of industries. For less ICT intensive industries it declined from about 2.28 or 2.67 percent per annum to about 1.16 or 1.17 percent per annum between the two periods, depending on whether industries were grouped according to industry classification A or B. Our disappointing estimates for the manufacturing sector seem consistent with those of other authors. For example, Black et al. (2003) found that the productivity performance of the manufacturing sector in 2002 was very similar to its productivity performance in 1988. Moreover, though for different earlier periods, Färe et al. (2003) found that the TFP performance of the majority of manufacturing industries was poorer during 1984-98 compared to 1978-84.

Turning to the services sector (industries 16-29), it can be observed that more than half of all industries showed an acceleration in LP growth rates from the earlier to the latter period (and half of the more ICT intensive services industries did so).

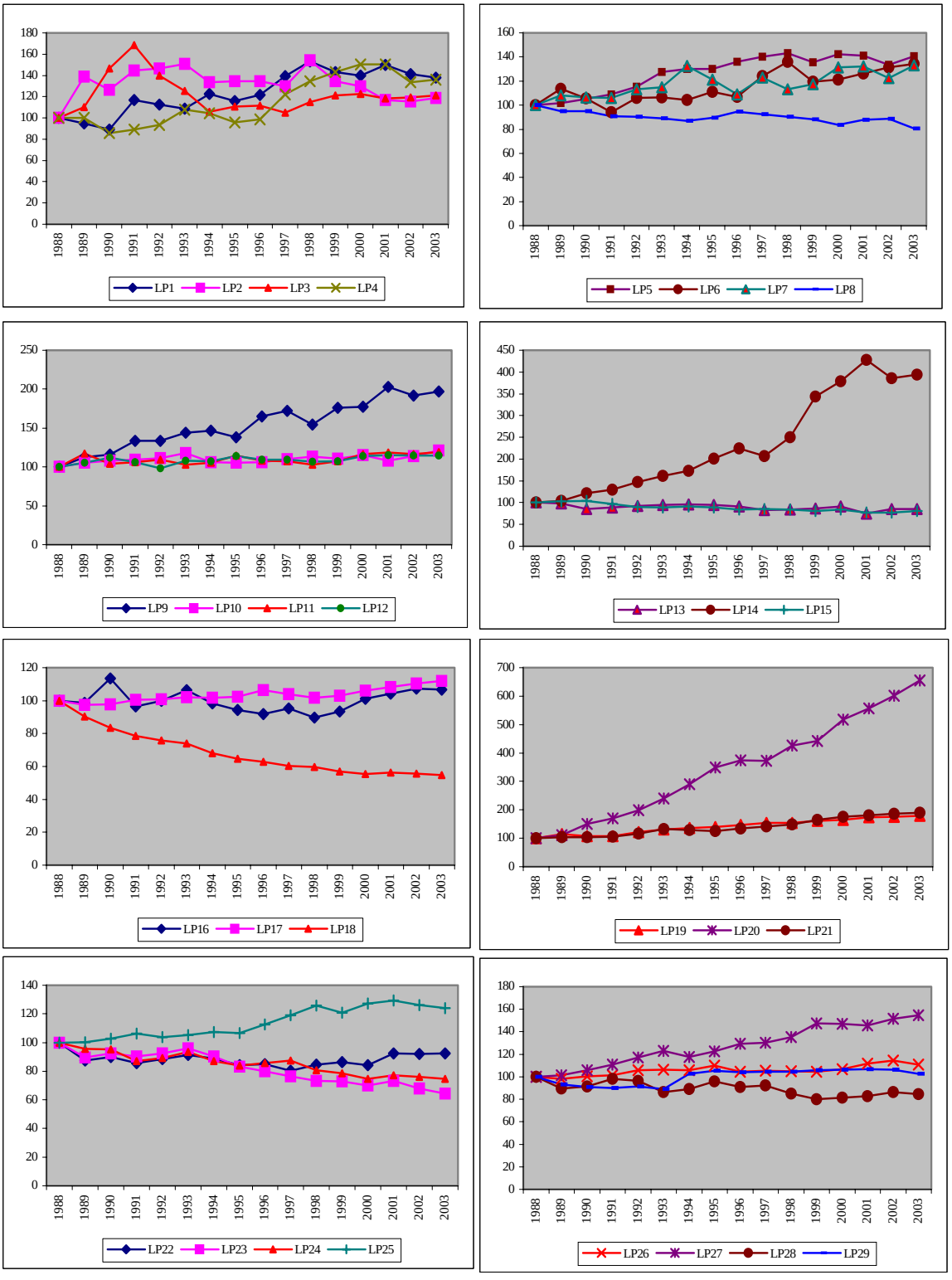
[13] But they do not seem unusual compared to the US, Australia and other OECD countries (see, e.g., Stiroh, 2002a; NOIE, 2004).

Table 3: Gross Output Based Labour Productivity Growth Rates*

		Annual Growth Rate (%)			Acceleration	Is the industry more ICT intensive?
		1988-92	1993-03	1988-03	1993-03 less 1988-92	
1	Agriculture	2.98	1.85	2.15	-1.13	No
2	Fishing	9.52	-1.89	1.16	-11.41	No
3	Forestry and Logging	8.40	-1.31	1.28	-9.71	No
4	Mining and Quarrying	-1.75	3.44	2.05	5.19	No
5	Food, Beverage and Tobacco Manufacturing	3.57	1.80	2.27	-1.77	No
6	Textiles and Apparel Manufacturing	1.43	2.16	1.96	0.73	No
7	Wood and Paper Products Manufacturing	3.06	1.47	1.89	-1.60	No
8	Printing, Publishing and Recorded Media	-2.59	-1.02	-1.44	1.56	Yes
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	7.28	3.53	4.53	-3.75	No
10	Non-Metallic Mineral Products Manufacturing	2.73	0.77	1.29	-1.96	No
11	Metal Product Manufacturing	2.20	0.77	1.15	-1.43	No
12	Machinery and Equipment Manufacturing	-0.48	1.43	0.92	1.91	Yes
13	Furniture and Other Manufacturing	-2.14	-0.61	-1.02	1.52	No
14	Electricity, Gas and Water Supply	9.63	8.97	9.15	-0.66	No
15	Construction	-2.68	-0.98	-1.43	1.70	No
16	Wholesale Trade	-0.01	0.60	0.44	0.61	Yes
17	Retail Trade (including motor vehicle repairs)	0.24	0.93	0.74	0.69	Yes
18	Accommodation, Cafes and Restaurants	-6.89	-2.97	-4.01	3.93	No
19	Transport and Storage	4.99	3.47	3.88	-1.52	Yes
20	Communication Services	17.13	10.87	12.54	-6.27	Yes
21	Finance, Insurance	3.69	4.52	4.30	0.82	Yes
22	Property Services	-3.08	0.39	-0.54	3.47	No
23	Ownership of Owner Occupied Dwellings	-1.98	-3.27	-2.93	-1.29	Yes
24	Business Services	-2.86	-1.62	-1.95	1.25	Yes
25	Government	0.95	1.61	1.43	0.65	Yes
26	Education	1.42	0.42	0.68	-1.00	Yes
27	Health and Community Services	4.00	2.51	2.91	-1.48	Yes
28	Cultural and Recreational Services	-0.92	-1.17	-1.10	-0.25	Yes
29	Personal and Other Community Services	-2.29	1.08	0.18	3.37	Yes
	Mean of labour productivity growth, all industries	1.92	1.30	1.47	-0.61	
	Mean, less ICT intensive industries	2.28	1.16	1.46	-1.12	Industry
	Mean, more ICT intensive industries	1.52	1.45	1.47	-0.07	Classification (A)
	Mean, less ICT intensive industries	2.67	1.17	1.57	-1.50	Industry
	Mean, more ICT intensive industries	1.39	1.40	1.39	0.01	Classification (B)

Notes: Industry Classification (A) refers to the more ICT intensive or less ICT intensive industries as specified in Table 2, whereas Industry Classification (B) includes industries 1, 6 and 13 in the more ICT intensive category. * The reported means are the unweighted mean labour productivity growth rates.

Figure 1: Labour Productivity Indices, 1988-2003 (1988=100%)



Note: LP_i shows the development of labour productivity of industry i (i=1,…,29) over time.
Source: Appendix Table A.3.

Comparing the means of LP growth rates for more ICT intensive and for less ICT intensive industries between our two sub-periods, it can be seen that for the former, LP growth has been similar during both periods, whereas for the latter, there has been a drastic decline in LP growth, thereby reversing the relative LP growth performance of the two categories of industries. The mean of the LP growth rates for more ICT intensive industries for the 1993-03 period was about 0.2 or 0.3 percent per annum higher than the mean of the LP growth rates for less ICT intensive industries. This fact is hidden if one looks only at the mean LP growth rates for the whole 1988-03 period (see the last five rows in Table 3).

It could be argued that much of our discussion of the estimates reported in Table 3 is misguided because the period 1988-92 is too short to provide a valid comparison with the period 1993-03. In that case, we would argue that the reader should view the LP growth rate estimates for the period 1993-03 as more representative than those for the whole period 1988-03, given the structural break in the data. In either case, the estimates in Table 3 suggest that there is now some evidence that more ICT intensive industries are beginning to outperform (in terms of LP growth) less ICT intensive industries (irrespective of whether industry classification A or B is used).

It should also be noted that some of the industry patterns of our LP growth estimates for NZ seem on the whole closer to those observed for the EU in contrast to those observed for the US. Ark et al. (2002) highlighted some key differences between EU and US LP growth experiences of more ICT intensive industries: During the second half of the 1990s, the US has shown much stronger productivity growth in, for example, retail and wholesale trade, but weaker LP growth in the telecommunications sector.[14] Like for EU countries, NZ LP growth rates are relatively low for retail and wholesale trade, but very high for 'Communications services'.

There are many reasons why NZ and many developed countries other than the US might so far show a smaller impact of ICT on productivity growth. It is well known that it takes time for businesses to realize the benefits of using ICTs (see, e.g., Basu et al., 2003, OECD, 2004). Moreover, OECD (2003c, p. 12) points out five factors that might explain the relative lack of benefits from ICT-use: (1) Aggregation across industries may disguise some of the impacts of ICT, i.e. strong effects in some industries may be counterbalanced by weak effects in others. (2) Outside the US firm networks are often less developed and conditions for effective ICT use may be less well established. (3) Differences in the measurement of output in the service sectors. (4) Other countries may not yet have benefited from network- or spillover-effects that could create a gap between the impacts of ICT at the level of individual firms and those that are measured at the macroeconomic level. (5) In a large and highly competitive market such as the US, firms investing in ICT may not always be the main beneficiaries of their investment. The benefits of ICT may accrue to consumers in the form of lower prices, better quality, improved convenience, and so on. In countries with less competition, firms might be able to extract a greater part of the returns, and spillover effects might be more limited. While it is beyond the scope of this paper to analyze the relevance of these factors in the NZ case, they suggest useful areas for further research.

4.2.2 Sensitivity Analysis

[14] Ark et al. (2002) found that strong productivity improvements in the US in retail/wholesale trade and securities accounted for much of the overall US-EU productivity growth gap since 1995.

There are a number of approaches to measuring productivity, and it has long been recognized that the range of productivity estimates can vary depending on the methodology and data used.[15] Therefore, the main results reported in Table 3 have to be subjected to sensitivity analyses to test the robustness of our main findings. In the following we are only able to do this with regard to some obvious alternative model specifications. Many measurement issues due to shortcomings in the underlying database cannot be addressed until more reliable industry level data are available.

4.2.2.1 How important is the likely influence of ICT producing industries?

In order to address the question whether our results are heavily influenced by ICT production instead of ICT use we dropped industries that contained ICT producing sub-sectors and re-calculated the (unweighted) means of LP growth rates for our two industry categories. This was done in two stages. First, we deleted industry 12 'Machinery and Equipment Manufacturing', which contained ICT manufacturing elements. Next, we also deleted services industries that contained ICT producing elements (see Appendix Table B.2). The results summarized in terms of the means are reported in Table 4. For ease of comparison the summary results from Table 3 are also shown. The differences between the means of LP growth rates for more ICT intensive versus less ICT intensive industries are hardly affected, i.e. our conclusions remain unchanged.

Table 4: Deleting Industries Containing ICT Producing Sub-Sectors

Table 3 estimates of means	1988-92	1993-03	1988-03	1993-03 less 1988-92	
Mean of labour productivity growth, all industries	1.92	1.30	1.47	-0.61	
Mean, less ICT intensive industries	2.28	1.16	1.46	-1.12	Industry
Mean, more ICT intensive industries	1.52	1.45	1.47	-0.07	Classification A
Mean, less ICT intensive industries	2.67	1.17	1.57	-1.50	Industry
Mean, more ICT intensive industries	1.39	1.40	1.39	0.01	Classification B
Without industry # 12					
Mean of labour productivity growth, all industries	2.00	1.30	1.48	-0.70	
Mean, less ICT intensive industries	2.28	1.16	1.46	-1.12	Industry
Mean, more ICT intensive industries	1.68	1.46	1.51	-0.22	Classification A
Mean, less ICT intensive industries	2.67	1.17	1.57	-1.50	Industry
Mean, more ICT intensive industries	1.50	1.39	1.42	-0.11	Classification B
Without industries # 12,16,20,23,24,28					
Mean of labour productivity growth, all industries	1.94	1.34	1.50	-0.60	
Mean, less ICT intensive industries	2.28	1.16	1.46	-1.12	Industry
Mean, more ICT intensive industries	1.30	1.69	1.59	0.39	Classification A
Mean, less ICT intensive industries	2.67	1.17	1.57	-1.50	Industry
Mean, more ICT intensive industries	1.15	1.54	1.43	0.38	Classification B

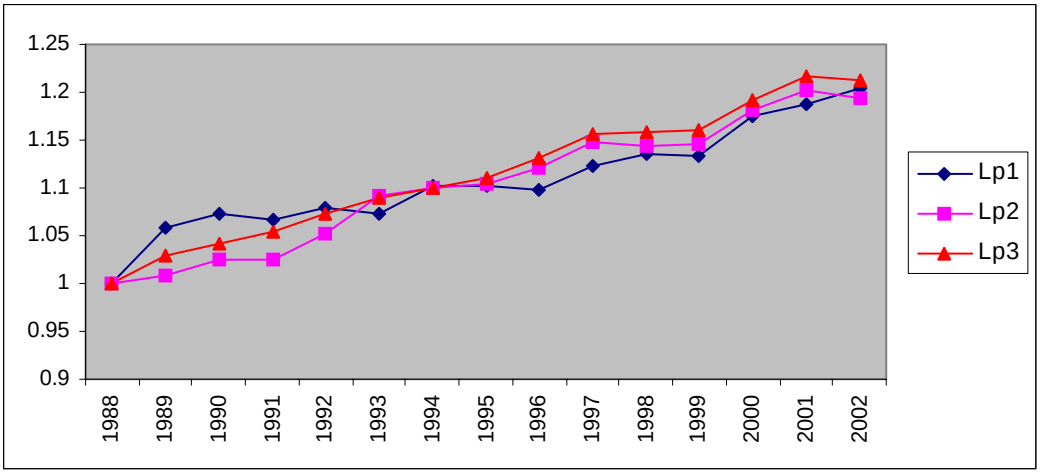
[15] See, e.g., Mawson et al. (2003) for a review of alternative approaches to measuring productivity.

4.2.2.2 Using the Chained Fisher Index to calculate labour productivity

The means of LP growth rates reported in Tables 3 and 4 are unweighted, i.e. they do not take the influence of industry size into account. Such an approach has, for example, been criticized by Diewert and Lawrence (1999, pp.98-99**)**. In order to assess whether our main results are robust in this regard, we also employed the Chained Fisher Index method to compute LP**.**[16] We first compared such estimates for the economy-wide mean LP growth rate with those reported in the study by Black et al. (2003). That study was selected for the comparison because we use the same production data as they did.[17] Next we compared unweighted and weighted estimates for more ICT intensive and less ICT intensive industries. Finally, we examined the weighted means of LP growth rates for our two groups of industries using Black et al.'s demarcation of time periods which they based on business cycles and structural breaks in the data.

Since Black et al. used value added based productivity, we also computed a value added based LP series. Figure 2 compares their LP series with our gross output and value added based LP series using the Chained Fisher Index. Table 5 compares their and our annual mean LP growth rates. Black et al.'s (2003) productivity series seem quite similar to ours in the sense that the mean LP growth rates for different sub-periods move in the same direction. However, Table 5 shows that our estimates are higher. This is likely due to differences in measuring labour input, i.e. Black et al. use hours worked, whereas we use the number of FTE employees.

Figure 2: Comparison with Black et al.'s (2003) Labour Productivity Series



Notes: Lp1 denotes Black et al.'s (2003) Labour Productivity (LP) series estimated using the Chained Fisher Index. Lp2 and Lp3 are, respectively, our estimated gross output and value added based LP series obtained using the Chained Fisher Index.

Table 5: Gross Output Based and Value Added Based Trend Annual Labour Productivity Growth Rates (Chained Fisher Indexed)

[16] The Fisher index is the geometric average of the Laspeyres and Paasche indexes. Chaining the index is likely to reduce any substitution bias due to changes in relative prices over time. For a brief introduction to index number methodology see, e.g., Diewert and Lawrence (1999), pp. 7-11.

[17] Their industry level estimates are only for one-digit industries, in contrast to our more disaggregate estimates. Our approach is better suited for distinguishing between more ICT intensive and less ICT intensive industries. However, this was achieved at the cost of having to use a less appropriate measure of labour input.

Business Cycles (periods taken from Black et al., 2003a, Table 1, panel 1)	Data taken from Appendix 2 in Black et al. (2003b)	Our data
Peak to peak: 1989-97	1.26%	1.61% (1.53%)
Trough to trough: 1990-98	0.78%	1.30% (1.41%)
Growth cycles: 1993-99	0.68%	1.15% (1.23%)
Growth pre- and post-1993 (periods taken from Black et al., 2003a, Table 1, panel 2)		
1988-93	1.36%	1.71% (1.74%)
1993-02	1.08%	1.23% (1.27%)
1988-02	1.30%	1.38% (1.27%)
Growth pre- and post-1993 (periods taken from Black et al., 2003a, Table 3)		
1988-93	1.36%	1.71% (1.74%)
1993-98	0.86%	1.28% (1.42%)
1988-98	1.25%	1.46% (1.35%)

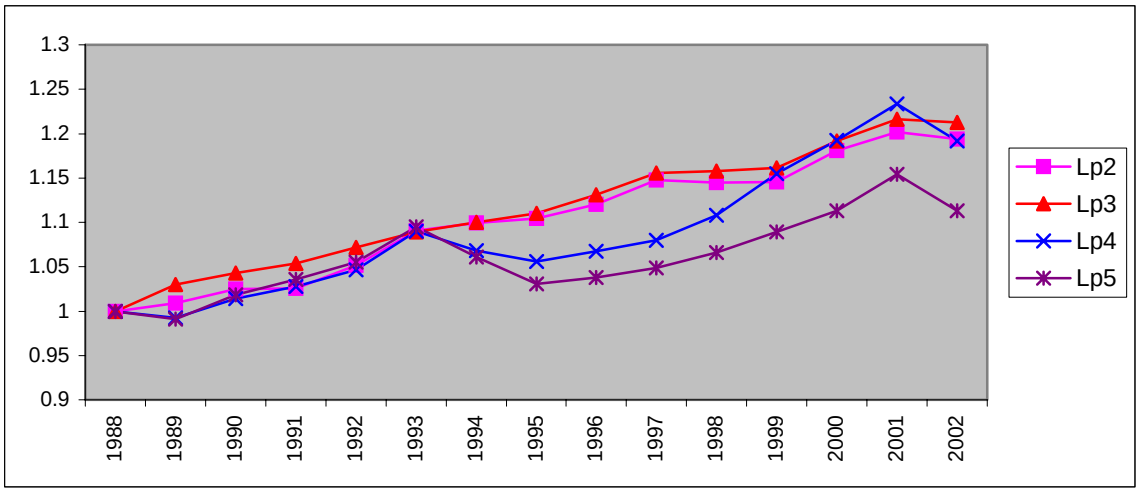
Notes: The value added and gross output based labour productivity estimates derived using our data are presented in the last column. Figures in parentheses are gross output based estimates.

Figure 3 compares the unweighted series with the weighted (Chained Fisher Indexed) series. It indicates that the weighted gross output and value added based productivity series have a similar trend, whereas the unweighted series began to diverge from the weighted ones in 1993. An exception is the unweighted gross output based series, i.e. the one used to obtain the main estimates reported in Table 3, which converged again to the weighted series for the post-1999 period.

After these preliminaries we can now present results for the weighted and unweighted means of LP growth rates for our two industry categories. Table 6 compares the unweighted mean growth rates of LP with the weighted ones for our entire sample period, and for the sub-periods used in Table 3, i.e. the periods 1988-92 and 1993-03.

Overall, both unweighted and weighted series show that the mean growth rates of aggregate LP productivity (i.e. across all industries), and those for less ICT intensive industries, declined between the 1988-92 period and the 1993-03 period (except for the mean growth rate of the gross output based Chained Fisher Indexed LP series, which did not change). For the post-1992 period, all LP series show that more ICT intensive industries experienced higher LP growth than less ICT intensive industries. This is obscured for all series if one looks only at the 1988-03 estimates, which are mostly very similar for both types of industry groups and industry classifications.

Figure 3: Chained Fisher Indexed Labour Productivity Series Versus Unweighted Labour Productivity Series



Notes: Lp2 and Lp3 are, respectively, our gross output based labour productivity and value added based LP estimates using the Chained Fisher Index. Lp4 and Lp5 are the unweighted estimates.

As far as acceleration or deceleration of LP growth over time is concerned, all LP series indicated that more ICT intensive industries performed much better on this criterion than did less ICT intensive industries. For the former, there was either an acceleration or a slight deceleration, whereas for the latter every series indicated a strong deceleration of LP growth. It again has to be pointed out that shortness of the 1988-92 period may invalidate the comparison of LP growth rates for the two periods because the calculations for the shorter period might not be robust to business cycle effects. However, it is comforting that consistent differences across all LP series emerged between estimates for the 1993-03 period and the 1988-03 period, strengthening our conclusions derived from the estimates reported in Table 3.

We also examined the weighted (Chained Fisher Indexed) means of LP growth rates for more ICT intensive and less ICT intensive industries for the time periods used in Black et al. (2003). This is reported in Table 7. It shows that for the post-1992 periods, LP growth rates for more ICT intensive industries were higher than LP growth rates for less ICT intensive industries, except for panels 1 (1993-99 period) and 3 (1993-98 period) using industry classification A. When industry classification (B) was used, average LP growth rates for more ICT intensive industries post-1992 were always higher than those of less ICT intensive industries. In short, there is some ambiguity with respect to the results which cannot be addressed until more detailed data allow us to use a finer industry classification that disaggregates the 'border-line' ICT intensive industries "Agriculture", "Textiles and Apparel Manufacturing" and "Furniture and Other Manufacturing".

Table 6: Comparison of Unweighted and Weighted Means of Gross Output and Value Added Based Labour Productivity Growth Rates

Value added based productivity (unweighted mean)	**1988-92**	**1993-03**	**1988-03**	**Acceler.**	
Mean of LP growth, all industries	2.04	1.31	1.50	-0.73	
Mean for less ICT intensive industries	2.97	1.16	1.65	-1.80	Industry
Mean for more ICT intensive industries	1.04	1.46	1.35	0.42	Classification A
Mean for less ICT intensive industries	3.46	0.57	1.34	-2.89	Industry
Mean for more ICT intensive industries	0.99	1.49	1.36	0.51	Classification B
Value added based productivity (Chained Fisher Index)	**1988-92**	**1993-03**	**1988-03**	**Acceler.**	
Mean of LP growth, all industries	1.74	1.17	1.32	-0.57	
Mean for less ICT intensive industries	2.88	0.90	1.43	-1.98	Industry
Mean for more ICT intensive industries	1.41	1.39	1.40	-0.02	Classification A
Mean for less ICT intensive industries	2.79	0.71	1.26	-2.08	Industry
Mean for more ICT intensive industries	1.49	1.36	1.39	-0.13	Classification B
Gross output based productivity (unweighted mean)	**1988-92**	**1993-03**	**1988-03**	**Acceler.**	
Mean of LP growth, all industries	1.92	1.30	1.47	-0.61	
Mean for less ICT intensive industries	2.28	1.16	1.46	-1.12	Industry
Mean for more ICT intensive industries	1.52	1.45	1.47	-0.07	Classification A
Mean for less ICT intensive industries	2.67	1.17	1.57	-1.50	Industry
Mean for more ICT intensive industries	1.39	1.40	1.39	0.01	Classification B
Gross output based productivity (Chained Fisher Index)	**1988-92**	**1993-03**	**1988-03**	**Acceler.**	
Mean of LP growth, all industries	1.25	1.25	1.25	0.00	
Mean for less ICT intensive industries	2.35	1.18	1.49	-1.18	Industry
Mean for more ICT intensive industries	1.18	1.47	1.39	0.29	Classification A
Mean for less ICT intensive industries	2.14	1.02	1.32	-1.12	Industry
Mean for more ICT intensive industries	1.26	1.38	1.35	0.12	Classification B

Note: See Table 3 for the definition of industry classifications (A) and (B).

Table 7: Comparison of Weighted (Chained Fisher Indexed) Means of Trend Annual LP Growth Rates for More ICT Intensive and Less ICT Intensive Industries

Business Cycles period taken from Black et al. (2003a, Table 1, panel 1)	Industry Classification (A)		Industry Classification (B)	
	less ICT intens.	more ICT intens.	less ICT intens.	more ICT intens.
1989-97	1.96%	1.56%	1.65%	1.61%
1990-98	1.85%	1.40%	1.34%	1.56%
1993-99	1.43%	1.34%	1.11%	1.34%
Growth pre- and post-1993 period taken from Black et al. (2003a, Table 1, panel 2)				
1988-93	2.37%	1.87%	2.44%	1.75%
1993-02	1.02%	1.64%	0.77%	1.57%
1988-02	1.40%	1.51%	1.16%	1.48%
Growth pre- and post-1993 period taken from Black et al. (2003a, Table 3)				
1988-93	2.37%	1.87%	2.44%	1.75%
1993-98	1.73%	1.34%	1.16%	1.50%
1988-98	1.98%	1.27%	1.55%	1.40%

Note: The LP growth rates are gross output based. Source: Appendix Table A3 data.

4.3 Dummy Variable Tests and Difference-In-Difference Regressions

4.3.1 Main Estimates

Regression analysis enables us to test more formally whether the LP changes documented in the previous sections can be linked to ICT intensity. Estimation of models (1) to (3) tests statistically whether LP has declined from the earlier to the later period and whether the differences in the mean growth rates for more ICT intensive and less ICT intensive industries are statistically significant. Table 8 on the next page reports the regression results. The parameter estimates were obtained using a generalized least squares estimator for pooled data, which corrects for within cross-section autocorrelation and heteroskedasticity, and employing different specifications of the estimator and data sample.[18]

Overall, most of the parameter estimates of our regression models reported in Table 8 were statistically significant and support our earlier results. The estimates of model 1 suggest that there was indeed a break in the data, i.e. LP growth rates declined post-1992. This is confirmed by the unweighted regression estimate for α_1 shown in column (I) and by the weighted regression estimate in column (V). The latter was obtained after deleting outliers, thereby improving on the estimate reported in column (III).

When testing for the difference between the mean growth rate of LP for more ICT intensive industries versus that for less ICT intensive industries (model 2) over the entire sample period 1988-03, a mixed picture emerged, depending on what industry classification and estimator was used. When industry classification A was used (see the regressions in columns I, III, V), both the unweighted and weighted regression estimates showed that the mean growth rate of LP for more ICT intensive industries was lower than that for less ICT intensive industries (compare the estimates for $\beta_0+\beta_1$ with those for β_0). Moreover, it seemed to have declined over time (the estimates for β_1 are negative). In contrast, when the 'borderline' more ICT intensive industries 'Agriculture', 'Textiles and Apparel Manufacturing' and 'Furniture and Other Manufacturing' were included as more ICT intensive in the weighted regressions (columns IV and VI, industry classification B), the mean growth rate of LP for more ICT intensive industries appeared to be higher than that for other industries, plus it seemed to have increased over time.

[18] For details of the estimation procedure, see Whistler et al. (2001, pp. 281-286).

Table 8: Regression Estimates of the Relationship Between ICT Intensity and Labour Productivity Growth: Models 1 to 3, 1988-2003.

	I	II	III	IV	V	VI
Industry Classification	**A**	**B**	**A**	**B**	**A**	**B**
Estimation Method	**Unweighted regression**	**Unweighted regression**	**Weighted regression**	**Weighted regression**	**Weighted regression**	**Weighted regression**
Model 1						
$\alpha 0$	1.636***		1.136***		1.144***	
	(0.138)		(0.102)		(0.127)	
$\alpha 0+\alpha 1$	1.133***		1.035***		0.872***	
	(0.079)		(0.060)		(0.148)	
$\alpha 1$	-0.503***		-0.101		-0.272*	
	(0.161)		(0.120)		(0.147)	
R-squared	*0.59*		*0.64*		*0.49*	
Number of Observations	435		435		405	
Model 2						
$\beta 0$	1.539***	1.593***	1.290***	0.423*	1.162***	0.379***
	(0.069)	(0.240)	(0.060)	(0.237)	(0.058)	(0.114)
$\beta 0+\beta 1$	0.832***	1.001***	0.852***	1.308***	0.547	1.140***
	(0.137)	(0.186)	(0.106)	(0.204)	(0.377)	(0.146)
$\beta 1$	-0.707***	-0.592	-0.437***	0.885**	-0.615*	0.743***
	(0.163)	(0.406)	(0.140)	(0.435)	(0.356)	(0.219)
R-squared	*0.72*	*0.63*	*0.77*	*0.72*	*0.67*	*0.36*
Number of Observations	435	435	435	435	405	405
Model 3						
$\delta 0$	2.496***	3.491***	1.738***	1.082**	1.629***	0.858***
	(0.144)	(0.294)	(0.124)	(0.442)	(0.821)	(0.231)
$\delta 0+\delta 1$	1.184***	1.000***	1.142***	0.246	1.000***	0.267**
	(0.085)	(0.173)	(0.071)	(0.260)	(0.056)	(0.123)
$\delta 1$	-1.312***	-2.491***	-0.596***	-0.836*	-0.629***	-0.591**
	(0.168)	(0.344)	(0.144)	(0.507)	(0.097)	(0.264)
$\delta 0+\delta 2$	0.196	0.158	0.499**	0.880**	0.348	0.869***
	(0.292)	(0.323)	(0.231)	(0.406)	(0.595)	(0.284)
$\delta 0+\delta 2+\delta 1+\delta 3$	1.033***	1.274***	0.963***	1.450***	-0.104	1.222***
	(0.376)	(0.460)	(0.224)	(0.663)	(0.555)	(0.368)
$\delta 1+\delta 3$	0.837**	1.116***	0.464*	0.570	-0.452	0.353
	(0.328)	(0.378)	(0.269)	(0.462)	(0.671)	(0.332)
$\delta 3$	2.149***	3.607***	1.060***	1.406	0.829	0.944*
	(0.320)	(0.641)	(0.321)	(0.947)	(0.644)	(0.521)
R-squared	*0.70*	*0.64*	*0.71*	*0.65*	*0.80*	*0.38*
Number of Observations	435	435	435	435	405	405

Notes: The dependent variable is the annual growth rate of labour productivity. Estimates reported in column (I) were obtained using pooled regression and industry classification A; those in column (II) using pooled regression and industry classification B. Estimates in column (III) were obtained using the square roots of employment as weights in (I); those in column (IV) using the square roots of employment as weights in (II). Regressions reported in column (V) drop industries 14 and 20 from (III). Regressions in column (VI) drop industries 14 and 20 from (IV). Three stars (***) indicate that the coefficient is significantly different from zero at the 1% level, two stars (**) indicate that it is significant at the 5% level, one star (*) indicates that it is significant at the 10% level. Figures in parentheses are standard errors corrected for heteroskedasticity and autocorrelation. Industry Classification A consists of the two groups of more ICT and less ICT intensive industries as specified in Table 2, whereas Industry Classification B includes industries 1, 6 and 13 in the more ICT intensive group of industries.

The estimates for the entire sample period may be misleading because of the break in the data in 1992/93. Therefore, model 2 was extended in such a way that estimates for the two types of industries were split into pre-1993 and post-1992 (model 3). The clear message derived from the estimates was that the LP growth rate for less ICT intensive industries declined greatly from the earlier to the latter period (see the first three rows of estimates for model 3). The drop in the LP growth rate was statistically significant in all regressions (see the estimates for δ_1). For more ICT intensive industries, the estimates suggested, on balance, the opposite. The post-1992 LP growth rate estimates were larger than the pre-1993 estimates, and the increase in the LP growth rate, i.e. the estimate for $\delta_1 + \delta_3$, was statistically significant, though not in all of the regressions (using weighted regressions with industries 14 and 20 deleted resulted in statistically insignificant estimates of the acceleration of the LP growth rate for more ICT intensive industries post-1992, as did use of the unweighted regression in case of industry classification B).

The difference-in-difference estimates for δ_3 from both weighted and unweighted regressions generally confirmed that, after 1992, the LP growth rate for more ICT intensive industries accelerated relative to that for less ICT intensive industries (although using industry classification B, outliers had to be deleted from the weighted regression before the estimate became statistically significant). The only other statistically insignificant estimate was obtained from the weighted regression using industry classification A with outliers deleted (column 5). We conducted further sensitivity analysis of the main results reported in Table 8, which seemed to confirm our main conclusions.

4.3.2 Sensitivity Analysis

The results reported in Table 8 were subjected to further sensitivity analysis in order to determine whether they were mainly due to ICT producing manufacturing and services sub-sectors, in contrast to heavily ICT using industries. Gordon (2000), for example, argued that the impact of ICT on productivity growth was confined mainly to the ICT producing manufacturing sectors, i.e. the production of computer hardware, peripherals, and telecommunications equipment. Although subsequent studies (e.g. Baily and Lawrence, 2001; Stiroh, 2002a) have contradicted Gordon's (2000) findings, it is appropriate to briefly explore the issue in the NZ context. As mentioned in section 4.2.2.1, given our database this could only be done in an approximate way by deleting those industries that included ICT producing components, thereby also deleting the other ICT intensive portions of these industries.

The estimates are reported in Table 9. The regressions reported in columns I and II show the effect of deletion of industry 12 (which contains ICT manufacturing sub-sectors) from weighted regressions for both industry classifications. The results were very similar to those reported in columns III and IV, Table 8, although there were the following differences: For model 1, the negative coefficient estimate of the change in the mean growth rate of LP post-1992 (α_1) became statistically significant; the estimate for the mean growth rate of LP for more ICT intensive industries over the whole period (β_1) in model 2 became statistically insignificant when industry classification A was used; in model 3, the acceleration of LP growth of more ICT intensive industries for the post-1992 period became statistically insignificant ($\delta_1+\delta_3$), whereas

the mean growth rate of LP for less ICT intensive industries ($\delta_0+\delta_1$) for the post-1992 period was statistically significant, for both industry classifications.

Next, all industries that included ICT goods and services components were deleted (column 3 regressions, Table 9). The qualitative results were little changed (compare columns I and III, Table 9, that both use industry classification A). The largest number of industries were excluded from regressions reported in columns IV and V, Table 9: In addition to deleting industries that included ICT producing components, industry 14, an outlier, was also deleted. In that case, all coefficient estimates became statistically significant at the 1% level. Compared to Table 8 regressions, the estimate for β_1 was again positive and statistically significant irrespective of which industry classification (A or B) was used. However, estimates for $\delta_1+\delta_3$, i.e. the acceleration of the LP growth rate for more ICT intensive industries after 1992, were negative, and the estimate for the differential acceleration of the LP growth rate for more ICT intensive industries relative to others (δ_3) produced contradictory estimates depending on which industry classification was used.

However, we would argue that the regression estimates shown in columns III, IV and V are non-representative because exclusion of so many industries from the data sample that include not only (small) ICT producing elements but mainly activities that are intensive in the use of ICT produced greatly biased estimates of the impact of ICT intensity on LP growth. This can only be addressed properly when more detailed industry level data become available.

When we only deleted industry 12 and two outliers (industries 14 and 20), but not other industries that included elements of ICT services production, the estimates again became qualitatively very similar to our main results reported in columns III and IV, Table 8 (the only major difference was that the estimate of δ_3 also became positive and statistically significant when industry classification B was used, see the model 3 regression in column VII, Table 9).

Table 9: Further Regressions – How Important is ICT Production?

	I	II	III	IV	V	VI	VII
Industry Classification	A	B	A	A	B	A	B
Estimation Method	Weighted regression, industry 12 deleted	Weighted regression, industry 12 deleted	Weighted regression, industries 12,16,20,23,24, 28 deleted	Like regression III, plus outlier industry 14 deleted	Like regression IV	Weighted regression, industries 12, 14, 20 deleted	Weighted regression, industries 12, 14, 20 deleted
Model 1							
$\alpha 0$	1.317***		1.710***	1.616***		0.972***	
	(0.075)		(0.075)	(0.073)		(0.085)	
$\alpha 0+\alpha 1$	0.986***		0.986***	1.300***		0.867***	
	(0.044)		(0.044)	(0.044)		(0.050)	
$\alpha 1$	-0.331***		-0.318***	-0.316***		-0.050	
	(0.088)		(0.122)	(0.087)		(0.099)	
R-squared	0.78		0.770	0.86		0.65	
Number of Observations	420		345	330		390	
Model 2							
$\beta 0$	1.270***	0.589***	1.279***	1.153***	0.412***	1.161***	0.360***
	(0.043)	(0.089)	(0.054)	(0.009)	(0.018)	(0.099)	(0.127)
$\beta 0+\beta 1$	0.821***	1.256***	1.610***	1.658***	1.720***	0.710***	1.039***
	(0.387)	(0.138)	(0.144)	(0.004)	(0.008)	(0.079)	(0.083)
$\beta 1$	-0.450	0.667***	0.331***	0.505***	1.308***	-0.451***	0.679***
	(0.416)	(0.211)	(0.163)	(0.004)	(0.010)	(0.157)	(0.187)
R-squared	0.87	0.66	0.78	0.99	0.99	0.67	0.67
Number of Observations	420	420	345	330	330	390	390
Model 3							
$\delta 0$	1.745***	1.047***	1.715***	1.540***	0.505***	1.678***	0.837***
	(0.038)	(0.150)	(0.107)	(0.000)	(0.052)	(0.176)	(0.249)
$\delta 0+\delta 1$	1.107***	0.476***	1.136***	1.028***	0.405***	0.979***	0.206
	(0.020)	(0.083)	(0.062)	(0.000)	(0.062)	(0.098)	(0.137)
$\delta 1$	-0.638***	-0.571***	-0.579***	-0.512***	-0.100***	-0.699***	-0.631**
	(0.040)	(0.171)	(0.124)	(0.000)	(0.029)	(0.203)	(0.285)
$\delta 0+\delta 2$	0.780**	1.125***	1.341***	1.715***	1.927***	0.455***	0.896***
	(0.324)	(0.272)	(0.278)	(0.000)	(0.022)	(0.137)	(0.141)
$\delta 0+\delta 2+\delta 1+\delta 3$	0.779**	1.292***	1.705***	1.635***	1.663***	0.802***	1.101***
	(0.383)	(0.170)	(0.336)	(0.000)	(0.251)	(0.083)	(0.100)
$\delta 1+\delta 3$	-0.001	0.167	0.364	-0.077***	-0.264***	0.347**	0.205
	(0.328)	(0.311)	(0.351)	(0.000)	(0.013)	(0.154)	(0.167)
$\delta 3$	0.637*	0.738	0.943***	0.435***	-0.164***	1.046***	0.836**
	(0.347)	(0.454)	(0.313)	(0.000)	(0.016)	(0.306)	(0.411)
R-squared	0.97	0.73	0.74	0.99	0.99	0.69	0.67
Number of Observations	420	420	345	330	330	390	390

Notes: Three stars (***) indicate that the coefficient is significantly different from zero at the 1% level, two stars (**) indicate that it is significant at the 5% level, one star (*) indicates that it is significant at the 10% level. Figures in parentheses are standard errors corrected for heteroskedasticity and autocorrelation. Industry Classification A consists of the two groups of more ICT and less ICT intensive industries as specified in Table 2, whereas Industry Classification B includes industries 1, 6 and 13 in the more ICT intensive group of industries.

5. SUMMARY AND CONCLUDING COMMENTS

This paper has examined the contribution of ICT to NZ's LP performance over the period 1988-2003. An ICT intensity index measuring the share of ICT inputs in total industry inputs was derived using NZ specific data. That enabled us to divide industries into more ICT intensive and less ICT intensive. Some special features of the NZ economy, such as the relative high ICT intensity of the agricultural sector, were also taken into account. While many factors are likely to have influenced LP growth, our analysis suggests that similar to other developed countries, LP growth of more ICT intensive industries in NZ improved relative to that of other industries. NZ's restraint overall LP performance was attributed to the decline of LP growth of less ICT intensive industries.

Like in much of the serious academic literature on the role of ICT in productivity growth, the interpretation of the meaning of our results lies in the eyes of the beholder. If, as argued by David (1990), it takes as long to realize the potential productivity increases from ICT as it did to realize them from electricity (i.e. four decades or more), one may argue that in the case of NZ, the productivity turn-up from large ICT investments is just around the corner, with the differential LP performance of more ICT intensive versus less ICT intensive industries during the period 1993-2003 being an early sign of this.

However, it is one thing to show some correlation between LP growth and relative ICT intensity, another to determine how much productivity growth can be attributed to technological, organizational and managerial innovations associated with ICT. Moreover, like in the case of the findings for European economies reported by Ark et al. (2002), further research is required to assertion whether our results are mainly due to measurement issues as compared to economic factors.[19]

In short, our results cannot be taken as conclusive evidence that ICT is having a positive impact on LP in NZ. Rather, they are suggestive of this and have to be strengthened by further research. This may include the following: (i) Further research on the NZ ICT intensity index: Data for more than one year could be used to derive the index, and to determine how it changed over time. Moreover, alternative indices should be explored, including use of a 'total' ICT intensity index that takes the amount of ICT embodied in non-ICT inputs into account instead of just measuring the direct use of ICT inputs. This would shed light on the question whether our division of industries into more ICT intensive and less ICT intensive is appropriate. (2) There is a need for more firm-level studies that can complement those at the economy-wide and industry level. In particular, such studies have highlighted the importance of complementary organizational investments, e.g. restructuring of business processes and work practices, as a pre-requisite for unlocking the potential of ICT for productivity improvements (see, e.g., Brynjolfsson and Hitt, 2000). Firm-level studies seem to find stronger ICT impacts on output and productivity growth (Ark, 2002). While some survey based NZ-specific studies exist (see, e.g., Knuckey et al., 2002, chapter 10), a lack of appropriate ICT investment, intangible investment and capital stock data has hampered research. (3) The relationship between LP and TFP for more ICT intensive versus less ICT intensive industries should be explored. However,

[19] See also Ahmad et al. (2003).

NZ data problems are likely to hamper such efforts. For example, Razzak (2003) has argued that TFP, in contrast to LP, is an unreliable measure of productivity in the NZ case. (4) Related to (3), there is a need to explicitly estimate ICT-related inter-industry spillovers. However, this would require the availability of industry-level ICT capital stocks.

One may speculate to what extent our LP growth estimates have been affected by NZ's low capital-labour ratio.[20] Could it be that relatively low physical capital accumulation has suppressed LP growth across the economy? In short, would more ICT intensive industries have shown an acceleration in LP growth in absolute terms had only the capital-labour ratio increased instead of being stagnant? The NZ Treasury view that the best bet for increasing the country's growth performance in the medium term is through capital deepening that raises LP (The Treasury, 2004, p. 48) seems to fit this hypothesis, although a thorough investigation of this question would have to address differences in the type of physical capital accumulation (i.e. ICT capital versus non-ICT capital), human capital accumulation, the role of embodied and disembodied knowledge spillovers, and the possible interactions of these and other growth determinants. It might raise some awkward questions about the productivity impact of the Employment Contracts Act that was in force during most of the 1990s, but other explanations of the stagnant capital-labour ratio are also possible (ibid., p. 25).

Raising productivity growth is seen as the main economic challenge facing NZ (OECD, 2004). There is already some indication that LP growth accelerated from the first to the second half of the 1990s.[21] We would like to interpret our findings as a piece of supporting evidence for the optimistic view that measurable LP improvements are in the pipeline, i.e. that the fruits of past economic reforms, present growth promoting policy settings and intangible organizational capital accumulation related to the use of ICT take time to materialize, but that they will eventually materialize, thereby lifting NZ's economic performance. Only time will tell whether this view is correct.

[20] For evidence of NZ's low capital-labour ratio during the 1990s compared to Australia's, see The Treasury (2004, pp. 24/5). LP growth can be decomposed into multifactor productivity growth and growth in the capital-labour ratio. Black et al. (2003) argue that the latter was responsible for NZ's relatively low LP growth after 1993. Multifactor productivity growth seems to have been similar in NZ and Australia during the 1990 (ibid.). See also OECD (2004).

[21] See OECD (2003b, p. 134), who report aggregate growth rates of GDP per hour worked for the two periods.

APPENDIX A: DATA CONSTRUCTION AND SOURCES

Gross Output, Value Added and Intermediate Consumption

Data on nominal industry gross output, GDP (value added), intermediate input and real industry value added were primarily drawn from the upgraded set of production accounts of the 30 two-digit industry categories of the Australian New Zealand Standard Industrial Classification (ANZSIC). We aggregated 'Central Government Administration and Defense' and 'Local Government Administration' to form the 'Government' sector, leaving the 29 two-digit industries used in this study. Annual March year nominal industry value added, gross output and intermediate input were available for the period 1987 to 1999, whereas annual March year real industry value added was available for the period 1988 to 2003.

To form the real industry gross output series for the period 1988 to 2003, we had to construct nominal industry gross output data for the period 2000 to 2003 using real industry value added, nominal industry intermediate input and the producer price index series. We first derived the industry value added implicit price deflators for the period 1988 to 1999 by dividing the nominal industry value added by real industry value added.[22] These price series were then projected forward from 2000 to 2003 by extrapolating the trend of the indices of the industry producer price (output prices). The nominal industry value added series for the period 2000 to 2003 were found by multiplying real industry value added with their implicit price deflators. The industry intermediate input series were then projected forward from 2000 to 2003 by extrapolating the trend in nominal industry value added. Finally, the nominal industry gross output series for the period 2000 to 2003 were obtained as the sum of nominal industry value added and industry intermediate input. The real industry gross output series for the period 1988 to 2003 were found by deflating nominal industry gross outputs by their implicit industry price deflators (see Table A.1 for our estimates of real industry gross outputs).

Labour Input

Statistics New Zealand produces several alternative employment series such as the Quarterly Employment Survey (QES), the Household Labour Force Survey (HLF), the Economic Survey of Manufacturing (MAN), and New Zealand Business Demography Statistics (BUD). Since the former three series do not produce industry employment data at the disaggregated level required for this study, we used 'full-time equivalent persons engaged (FTE)' employment data from the BUD. Box A.1 summaries key characteristics of these statistics.

22 Theoretically, the real industry value added series should be measured by subtracting a constant price value of intermediate inputs from a constant price value of gross output, a technique known as double deflation. Statistics New Zealand, however, constructs the real industry value added series for the upgraded set of accounts by compiling a Laspeyres volume index of the component in question, using the previous year's prices as weights; and then chaining the sequence of annual movements to produce a continuous time series (Statistics New Zealand, 2003). Therefore, using the implicit price deflators to derive real industry gross output is appropriate.

BUD reports annual February FTE data. Over the years, industry coverage has changed, as has the industrial classification used (i.e. the shift to ANZSIC) (see http://www.stats.govt.nz). To form comparable industry productivity series for the period 1988 to 2003 we had to adjust the FTE employment estimates for some industries that were excluded from the BUD census. As noted in Box A.1, 'Agriculture and Livestock Production' (part of industry #1 in this study) were excluded for most of the census years. We constructed the FTE employment series for industry #1 using HLF employment data and hours worked from Diewert and Lawrence (1999) (hereafter refers to DL data). Number of person employment from HLF data was available for the aggregation of industries #1 to #3 for the period 1997-03, whereas hours worked for industries #1 to #3 from DL data were available for the period 1978-1998. To construct the FTE employment series for industry #1, hours worked of industries #1 to #3 from DL data were aggregated and projected forward to the period 1997 to 2003 using the trend growth of the HLF employment series. Then, number of FTE employment for the aggregation of industries #1 to #3 in 2003 was estimated using the ratio of number of FTE employment to number of person employment. The rest of the number of FTE employment series of the aggregation of industries #1 to #3 were backdated to 1987 by extrapolating with the trend of the aggregation hours worked of industries #1 to #3. Finally, the number of FTE employment for industry #1 was found by subtracting the number of FTE employment of industries #2 and #3. We also had to construct the number of FTE employment series for industries #22 to #24, as NZSIC 82302, NZSIC83113, and NZSIC 83121 were excluded from these industries for the periods noted in Box A.1. First, aggregated ANZSIC FTE employment for these three industries was backdated by extrapolating with the trend of the OECD STAN employment data. Then, the share of each industry in 1995 was used to split the aggregate data for the rest of the backdated period. As for other industries, the FTE data were constructed without adjustment for excluded industries because employment in those industries was small. The ANZSIC FTE employment series were backdated by extrapolating with the trend of the NZSIC employment series (see Table A.2 for the estimation result).

Box A.1: Key Characteristics of the New Zealand Business Demography Statistics (BUD)

Employment definition and data availability
Full-time equivalent employment (FTE) is defined as the total number of employees and working proprietors working full-time plus half the number of employees and working proprietors working part-time. Employees and working proprietors working 30 hours or more per week are defined as full-time. Those working less than 30 hours per week are defined as part-time. The FTE data are available at the 5-digit industry level. It is an annual February year series published from 1987 onward.

Businesses covered
BUD is a census based on the New Zealand Business Frame. Business records on the Business Frame were compiled from numbers of compulsory GST registrations of enterprises for the period 1987 to 1994 and from numbers of economically significant enterprises for the period 1995 onwards. An enterprise is said to be economically significant if it meets one or more of the following criteria: It has more than $30,000 annual GST expenses or sales; it has more than two full-time equivalent paid employees; it is in a GST exempt industry (except for residential property leasing and rental); it is part of a group of enterprises; it is registered for GST and involved in agriculture or forestry.

Industry coverage
From 1997 onwards, the selection criteria and standard published industry categories for the business demographic statistics have been based on the ANZSIC. In 1996, the statistics were published using ANZSIC, but the selection criteria were based on the New Zealand Standard Industrial Classification (NZSIC). In recent years, more industries have been included in BUD. Historically, most of these industries had been excluded because they contained a large proportion of enterprises that were not registered for GST, or a large proportion of enterprises that fell below the threshold of economic significance. Details are indicated below:

Industries excluded from BUD (and years of exclusion)

NZSIC 11111-11199: Agriculture and livestock production	1987-1996
ANZSIC 01110-01699: Agriculture and livestock production	1997, 1999-2001
NZSIC 82302: Self-employed insurance commission agents	1987-1993
NZSIC 83113: Self-employed real estate commission agents	1987-1993
NZSIC 83121: Residential property leasing and rental	1987-1996
NZSIC 83123: Commercial property leasing and rental	1987-1995
NZSIC 93402: Child care services	1987-1995
NZSIC 93403: Residential and non-residential care services	1987-1995
NZSIC 93500: Business, professional and labour organisations	1987-1995
NZSIC 93910: Religious organisations	1987-1996
NZSIC 93990: Social and community groups	1987-1996
NZSIC 94402: Sporting and recreation services	1987-1996

Some limitations of the data
BUD has a number of recognized limitations, for example (i) the non-coverage of enterprises that fall below the $30,000 turnover threshold, (ii) the exclusion of enterprises in some industries (see the list above), (iii) lags in dropping businesses that fall below the inclusion threshold, (iv) discrepancies due to lack of one-to-one correspondence between ANZSIC and NZSIC, etc.

Source: Statistics New Zealand (http://www.stats.govt.nz).

Table A.1: Real Industry Gross Output data at 1995/96 Prices (Million $NZ)

		1988	1989	1990	1991	1992	1993	1994	1995
1	Agriculture	8821	8316	7780	9770	9373	8913	10214	9950
2	Fishing	590	730	678	766	808	833	750	795
3	Forestry and Logging	1712	1747	1983	2253	2238	2152	2251	2603
4	Mining and Quarrying	1976	1876	1489	1621	1745	1881	1946	1885
5	Food, Beverage and Tobacco Manufacturing	13509	13885	13472	13474	14170	15916	16727	16535
6	Textiles and Apparel Manufacturing	3643	3630	3280	2623	2764	2851	2943	3183
7	Wood and Paper Products Manufacturing	5155	4949	4812	4832	4961	5193	6501	6349
8	Printing, Publishing and Recorded Media	3383	3148	2962	2845	2692	2684	2729	2939
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	3735	3899	3861	4228	4160	4463	4737	4733
10	Non-Metallic Mineral Products Manufacturing	1732	1508	1371	1265	1185	1310	1259	1367
11	Metal Product Manufacturing	4584	4880	4257	4064	3854	3664	4109	4747
12	Machinery and Equipment Manufacturing	6805	6245	6574	5642	4847	5403	5806	6606
13	Furniture and Other Manufacturing	1525	1367	1267	1259	1323	1348	1591	1597
14	Electricity, Gas and Water Supply	4215	4037	4096	4399	4482	4331	4669	5026
15	Construction	15226	14124	14056	12521	10595	10306	11346	12527
16	Wholesale Trade	16210	15670	17933	15329	15638	16739	16842	17381
17	Retail Trade (including motor vehicle repairs)	9365	8974	9359	9255	9075	9193	9684	10263
18	Accommodation, Cafes and Restaurants	4380	4037	3822	3527	3550	3522	3452	3537
19	Transport and Storage	6750	7062	6464	6684	7092	7593	8226	9113
20	Communication Services	1884	1989	2438	2615	2804	3136	3627	4230
21	Finance, Insurance	7291	7147	7075	7024	7429	7756	7825	7911
22	Property Services	6519	6272	6373	6328	6463	6505	6953	7220
23	Ownership of Owner Occupied Dwellings	7936	7835	7968	8102	8222	8326	8583	8675
24	Business Services	9560	10051	9919	9430	9562	9766	9999	10558
25	Government	8147	7693	7990	8318	7904	8046	8158	8000
26	Education	3208	3305	3567	3771	3984	4181	4430	4630
27	Health and Community Services	4552	4786	4799	5160	5479	5710	5782	5895
28	Cultural and Recreational Services	2426	2356	2495	2741	2804	2639	2932	3487
29	Personal and Other Community Services	1546	1487	1487	1447	1453	1450	1713	1871

Table A.1 (continued)

		1996	1997	1998	1999	2000	2001	2002	2003
1	Agriculture	10332	11329	12081	11316	11955	12175	12338	12419
2	Fishing	807	818	857	824	797	726	732	738
3	Forestry and Logging	2633	2531	2628	2661	2961	3113	3290	3566
4	Mining and Quarrying	1970	2377	2395	2501	2432	2492	2410	2461
5	Food, Beverage and Tobacco Manufacturing	17881	18655	19189	17525	17841	18459	18592	20428
6	Textiles and Apparel Manufacturing	2829	2998	3000	2520	2613	2624	2734	2728
7	Wood and Paper Products Manufacturing	5721	6305	5783	5768	6843	6815	6426	7169
8	Printing, Publishing and Recorded Media	3086	3027	2948	2761	2550	2589	2662	2407
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	5524	5486	5055	5417	5606	6184	6075	6305
10	Non-Metallic Mineral Products Manufacturing	1436	1484	1526	1501	1529	1435	1524	1703
11	Metal Product Manufacturing	4574	4593	4443	4455	4947	4925	5046	5310
12	Machinery and Equipment Manufacturing	6445	6493	6149	5947	6155	6396	6651	6828
13	Furniture and Other Manufacturing	1462	1316	1289	1306	1415	1199	1351	1417
14	Electricity, Gas and Water Supply	5455	5132	5432	5964	5753	6056	5646	6140
15	Construction	12869	13695	14041	13494	15359	13893	14170	15811
16	Wholesale Trade	17604	18889	18311	18505	20409	21306	22083	22597
17	Retail Trade (including motor vehicle repairs)	10607	10676	10569	10751	11330	11570	12049	12736
18	Accommodation, Cafes and Restaurants	3534	3586	3607	3561	3751	3826	3962	4134
19	Transport and Storage	9915	10535	10828	11039	11638	12383	12979	13526
20	Communication Services	4761	5382	5779	6680	7768	8739	9459	10011
21	Finance, Insurance	8681	9059	9475	9881	10172	10362	11066	11857
22	Property Services	7576	7470	7677	7641	7822	7965	8309	8569
23	Ownership of Owner Occupied Dwellings	8694	8680	8640	8692	8698	8716	8774	8891
24	Business Services	11239	11934	12181	12759	13174	13936	14457	15044
25	Government	8260	8105	8579	8050	7999	8163	8293	8595
26	Education	4782	4871	4959	5093	5117	5281	5517	5616
27	Health and Community Services	6285	6678	7237	8149	8519	8897	9714	10194
28	Cultural and Recreational Services	3568	3908	3758	3743	4005	4221	4665	4669
29	Personal and Other Community Services	1913	1944	1968	2049	2152	2182	2220	2268

Source: Statistics NZ and authors' estimates.

Table A.2: Full Time Equivalent Number of Persons Employed by Industry

		1988	1989	1990	1991	1992	1993	1994	1995
1	Agriculture	128535	127732	127201	121932	121241	119333	121233	124904
2	Fishing	4602	4103	4192	4132	4306	4300	4384	4614
3	Forestry and Logging	6441	5972	5098	5030	6019	6449	8021	8841
4	Mining and Quarrying	4379	4152	3844	4026	4148	3873	4143	4365
5	Food, Beverage and Tobacco Manufacturing	60998	61741	57952	55761	55473	56332	58151	57499
6	Textiles and Apparel Manufacturing	35373	30980	30237	27090	25345	25981	27377	27804
7	Wood and Paper Products Manufacturing	25334	22468	22195	22386	21569	22216	24098	25784
8	Printing, Publishing and Recorded Media	22415	21983	20657	20747	19779	19965	20806	21768
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	23370	21695	20858	19773	19454	19417	20220	21467
10	Non-Metallic Mineral Products Manufacturing	8639	7146	6352	5779	5299	5543	5932	6474
11	Metal Product Manufacturing	29460	26820	26268	24684	22674	22981	25101	26623
12	Machinery and Equipment Manufacturing	52068	45431	45044	40742	37808	38216	41477	44322
13	Furniture and Other Manufacturing	13991	12699	13637	13016	13219	13077	15286	15515
14	Electricity, Gas and Water Supply	18326	16886	14586	14712	13259	11700	11756	10899
15	Construction	90594	81995	80271	77193	70173	69164	74165	84237
16	Wholesale Trade	80833	79232	78806	79275	77996	78443	85431	91989
17	Retail Trade (including motor vehicle repairs)	156378	153953	159754	153910	150103	150417	158935	167572
18	Accommodation, Cafes and Restaurants	44250	45227	46303	45379	47251	48140	51293	55270
19	Transport and Storage	60466	55029	54282	55284	52029	51993	54286	58129
20	Communication Services	34004	32557	29237	27884	25501	23533	22547	21818
21	Finance, Insurance	54071	50754	50724	49043	47528	43587	45273	46667
22	Property Services	18209	20049	19810	20608	20422	19889	21833	23963
23	Ownership of Owner Occupied Dwellings	4874	5366	5302	5516	5466	5324	5844	6414
24	Business Services	83235	91646	90550	94202	93350	90916	99800	109537
25	Government	66918	62993	63923	64236	62491	62940	62497	61578
26	Education	68610	71888	75856	79686	80506	84125	89450	90202
27	Health and Community Services	92509	96001	92219	94577	94886	94188	100057	97767
28	Cultural and Recreational Services	17238	18680	19384	19805	20667	21657	23337	25823
29	Personal and Other Community Services	37587	38877	39783	39070	38730	39556	40557	43170

Table A.2 (continued)

		1996	1997	1998	1999	2000	2001	2002	2003
1	Agriculture	123628	118629	114795	115225	124575	118435	127150	131120
2	Fishing	4683	4910	4340	4770	4790	4840	4940	4840
3	Forestry and Logging	8879	9090	8620	8270	9100	9920	10370	11070
4	Mining and Quarrying	4430	4320	3940	3880	3590	3680	4000	4010
5	Food, Beverage and Tobacco Manufacturing	59315	60040	60550	58370	56540	59180	62990	65610
6	Textiles and Apparel Manufacturing	25732	23470	21450	20470	20940	20200	20230	19730
7	Wood and Paper Products Manufacturing	25818	25180	25080	24170	25640	25380	25800	26530
8	Printing, Publishing and Recorded Media	21649	21730	21650	20740	20210	19580	19860	19790
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	20978	19930	20490	19270	19800	19060	19820	20000
10	Non-Metallic Mineral Products Manufacturing	6740	6730	6720	6770	6610	6620	6660	7000
11	Metal Product Manufacturing	27158	27460	27730	26740	27240	26780	27870	28710
12	Machinery and Equipment Manufacturing	45101	45480	44010	42310	41240	42450	44320	45500
13	Furniture and Other Manufacturing	14679	14500	14070	13830	14320	14680	14620	15150
14	Electricity, Gas and Water Supply	10567	10800	9440	7540	6600	6150	6360	6770
15	Construction	91360	95820	99200	100150	108230	106530	110000	116610
16	Wholesale Trade	95672	98820	101710	98680	100730	101930	102700	105500
17	Retail Trade (including motor vehicle repairs)	166679	171330	173380	174280	178260	178720	182220	190200
18	Accommodation, Cafes and Restaurants	56835	60190	61080	63250	68480	68700	71710	76250
19	Transport and Storage	60419	61590	63200	61250	63410	63570	65990	67740
20	Communication Services	22926	26090	24520	27270	27080	28280	28410	27550
21	Finance, Insurance	47680	47280	47090	44500	43100	42420	44160	46150
22	Property Services	24948	26040	25400	24700	25940	24110	25250	25940
23	Ownership of Owner Occupied Dwellings	6678	6970	7260	7340	7650	7320	7920	8470
24	Business Services	114040	119030	131290	141280	153770	157120	165210	175430
25	Government	60215	56000	56060	54790	51600	51840	54020	56940
26	Education	98023	98950	101040	104430	102650	101010	103150	108370
27	Health and Community Services	98775	104010	108600	112270	117770	124300	130450	133880
28	Cultural and Recreational Services	27826	30090	31340	33160	34910	36290	38430	39140
29	Personal and Other Community Services	44634	45270	45830	47090	49290	49640	50710	53670

Source: Statistics NZ's INFOS database and authors' estimates.

Table A.3: Labour Productivity Index

		1988	1989	1990	1991	1992	1993	1994	1995
1	Agriculture	100	95	89	117	113	109	123	116
2	Fishing	100	139	126	145	146	151	133	134
3	Forestry and Logging	100	110	146	169	140	126	106	111
4	Mining and Quarrying	100	100	86	89	93	108	104	96
5	Food, Beverage and Tobacco Manufacturing	100	102	105	109	115	128	130	130
6	Textiles and Apparel Manufacturing	100	114	105	94	106	107	104	111
7	Wood and Paper Products Manufacturing	100	108	107	106	113	115	133	121
8	Printing, Publishing and Recorded Media	100	95	95	91	90	89	87	89
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	100	112	116	134	134	144	147	138
10	Non-Metallic Mineral Products Manufacturing	100	105	108	109	112	118	106	105
11	Metal Product Manufacturing	100	117	104	106	109	102	105	115
12	Machinery and Equipment Manufacturing	100	105	112	106	98	108	107	114
13	Furniture and Other Manufacturing	100	99	85	89	92	95	95	94
14	Electricity, Gas and Water Supply	100	104	122	130	147	161	173	201
15	Construction	100	102	104	97	90	89	91	88
16	Wholesale Trade	100	99	113	96	100	106	98	94
17	Retail Trade (including motor vehicle repairs)	100	97	98	100	101	102	102	102
18	Accommodation, Cafes and Restaurants	100	90	83	79	76	74	68	65
19	Transport and Storage	100	115	107	108	122	131	136	140
20	Communication Services	100	110	150	169	198	240	290	350
21	Finance, Insurance	100	104	103	106	116	132	128	126
22	Property Services	100	87	90	86	88	91	89	84
23	Ownership of Owner Occupied Dwellings	100	90	92	90	92	96	90	83
24	Business Services	100	95	95	87	89	94	87	84
25	Government	100	100	103	106	104	105	107	107
26	Education	100	98	101	101	106	106	106	110
27	Health and Community Services	100	101	106	111	117	123	117	123
28	Cultural and Recreational Services	100	90	91	98	96	87	89	96
29	Personal and Other Community Services	100	93	91	90	91	89	103	105

Table A.3 (continued)

		1996	1997	1998	1999	2000	2001	2002	2003
1	Agriculture	122	139	153	143	140	150	141	138
2	Fishing	134	130	154	135	130	117	116	119
3	Forestry and Logging	112	105	115	121	122	118	119	121
4	Mining and Quarrying	99	122	135	143	150	150	134	136
5	Food, Beverage and Tobacco Manufacturing	136	140	143	136	142	141	133	141
6	Textiles and Apparel Manufacturing	107	124	136	120	121	126	131	134
7	Wood and Paper Products Manufacturing	109	123	113	117	131	132	122	133
8	Printing, Publishing and Recorded Media	94	92	90	88	84	88	89	81
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	165	172	154	176	177	203	192	197
10	Non-Metallic Mineral Products Manufacturing	106	110	113	111	115	108	114	121
11	Metal Product Manufacturing	108	107	103	107	117	118	116	119
12	Machinery and Equipment Manufacturing	109	109	107	108	114	115	115	115
13	Furniture and Other Manufacturing	91	83	84	87	91	75	85	86
14	Electricity, Gas and Water Supply	224	207	250	344	379	428	386	394
15	Construction	84	85	84	80	84	78	77	81
16	Wholesale Trade	92	95	90	94	101	104	107	107
17	Retail Trade (including motor vehicle repairs)	106	104	102	103	106	108	110	112
18	Accommodation, Cafes and Restaurants	63	60	60	57	55	56	56	55
19	Transport and Storage	147	153	153	161	164	174	176	179
20	Communication Services	375	372	425	442	518	558	601	656
21	Finance, Insurance	135	142	149	165	175	181	186	191
22	Property Services	85	80	84	86	84	92	92	92
23	Ownership of Owner Occupied Dwellings	80	76	73	73	70	73	68	64
24	Business Services	86	87	81	79	75	77	76	75
25	Government	113	119	126	121	127	129	126	124
26	Education	104	105	105	104	107	112	114	111
27	Health and Community Services	129	130	135	148	147	145	151	155
28	Cultural and Recreational Services	91	92	85	80	82	83	86	85
29	Personal and Other Community Services	104	104	104	106	106	107	106	103

Source: Estimated using data from Tables A.1 and A.2. The labour productivity index is defined as the quantity index of real gross output divided by the quantity index of the FTE number of persons employed.

APPENDIX B: DETAILED INFORMATION FROM THE 1996 NEW ZEALAND INPUT-OUTPUT TABLE USED FOR ESTIMATING THE 'ICT INTENSITY INDEX'.

Table B.1: Aggregation of the Inter-Industry Transactions

	29 industries	126 industries	ANZSIC
1	Agriculture	Other horticulture	A011100, A011200, A011300
		Apple and pear growing	A011500
		Kiwifruit growing	A011700
		Other fruit growing	A011400, A011600, A011910, A011920, A011990
		Mixed livestock and cropping	A012100, A012200, A015910
		Sheep and beef cattle farming	A012300, A012400, A012500
		Dairy cattle farming	A013000
		Other farming	A014100, A014200, A015100, A015200, A015300, A015930. A015990. A016910. A016920. A016990
		Services to agriculture, hunting and trapping	A021200, A021300, A021900, A022000
2	Fishing	Forestry	A030100
		Services to forestry	A030300
		Logging	A030200
3	Forestry and Logging	Fishing	A041100, A041300, A041400, A041500, A041900, A042000
4	Mining and Quarrying	Coal mining	B110100, B110200
		Services to mining	B151400, B152000
		Other mining and quarrying	B131100, B131200, B131300, B131400, B131500, B131600. B131700. B131900. B141100. B141900.
		Oil & gas extraction	B120000
		Oil & gas exploration	B151100, B151200
5	Food, Beverage and Tobacco Manufacturing	Meat processing	C211100
		Poultry processing	C211200
		Bacon, ham and smallgood manufacturing	C211300
		Dairy product manufacturing	C212100, C212200, C212900
		Fruit and vegetable, oil and fat, cereal and flour manufacturing	C213000, C214000, C215100, C215200
		Bakery, sugar and confectionery manufacturing	C216100, C216200, C216300, C217100, C217200
		Seafood processing	C217300
		Other food manufacturing	C217400, C217900
		Soft drink, cordial and syrup manufacturing	C218100
		Beer, wine, spirit and tobacco manufacturing	C218200, C218300, C218400, C219000
6	Textiles and Apparel Manufacturing	Textile manufacturing	C221100, C221200, C221300, C221400, C221500, C222100. C222200. C222300. C222900. C223100.
		Clothing manufacture	C224000
		Footwear manufacture	C225000
		Other leather product manufacturing	C226110, C226120, C226200
7	Wood and Paper Products Manufacturing	Log sawmilling and timber dressing	C231100, C231200, C231300
		Other wood product manufacturing	C232100, C232200, C232300, C232900
		Paper & paper product manufacturing	C233100, C233200, C233300, C233400, C233900

Table B.1 (continued)

	29 industries	126 industries	ANZSIC
8	Printing, Publishing and Recorded Media	Printing and services to printing	C241100, C241200, C241300
		Publishing, recorded media manufacturing	C242100, C242200, C242300, C243000
9	Petroleum, Chemical, Plastics and Rubber Products Manufacturing	Petroleum refining	C251000
		Petroleum and coal product manufacturing nec	C252000
		Fertiliser manufacturing	C253100
		Other industrial chemical manufacturing	C253200, C253300, C253400, C253500
		Medicinal, detergent and cosmetic manufacturing	C254300, C254500, C254600
		Other chemical product manufacturing	C254100, C254200, C254400, C254700, C254900
		Rubber manufacturing	C255100, C255900
		Plastic product manufacturing	C256100, C256200, C256300, C256400, C256500,
10	Non-Metallic Mineral Products Manufacturing	Glass and glass product and ceramic manufacturing	C261000, C262100, C262200, C262300, C262900
		Other non-metallic mineral product manufacturing	C263100, C263200, C263300, C263400, C263500,
11	Metal Product Manufacturing	Basic metal manufacturing	C271100, C271200, C271300, C272100, C272200, C272300. C272900. C273100. C273200. C273300
		Structural, sheet and fabricated metal product manufacturing	C274100, C274200, C274900, C275100, C275900, C276100. C276200. C276300. C276400. C276500.
12	Machinery and Equipment Manufacturing	Motor vehicle and part manufacturing	C281100, C281200, C281300, C281900
		Ship and boat building	C282100, C282200
		Other transport equipment manufacturing	C282300, C282400, C282900
		Photographic and scientific equipment manufacturing	C283100, C283200, C283900
		Electronic equipment and appliance manufacturing	C284100, C284200, C284900, C285100, C285200, C285300. C285400. C285900
		Agricultural machinery manufacturing	C286100
		Other industrial machinery & equipment manufacturing	C286200, C286300, C286400, C286500, C286600, C286700, C286900
13	Furniture and Other Manufacturing	Prefabricated building manufacturing	C291100, C291900
		Furniture manufacturing	C292100, C292200, C292300, C292900
		Other manufacturing	C294100, C294200, C294900
14	Electricity, Gas and Water Supply	Electricity generation	D361000pt
		Electricity transmission	D361000pt
		Electricity supply	D361000pt
		Gas supply	D362000
		Water supply	D370100
15	Construction	Residential building construction	E411100pt, E411200pt
		Owner builders	E411100pt, E411200pt
		Non residential building construction	E411300
		Non building construction	E412100, E412200
		Site preparation services	E421000
		Building structure services	E422100, E422200, E422300, E422400
		Plumbing services	E423100
		Installation trade services	E423200, E423300, E423400
		Building completion services	E424100, E424200, E424300, E424400, E424500
		Other construction services	E425100, E425900

Table B.1 (continued)

	29 industries	126 industries	ANZSIC
16	Wholesale Trade	Wholesale trade	F451100, F451200, F451900, F452100, F452200, F452300, F453100, F453900, F461100, F461200, F461300, F461400, F461500, F461900, F462100, F462200, F462300, F462400, F471300pt, F471500pt, F471500pt, F471100, F471200, F471300pt, F471400, F471500pt, F471600, F4
17	Retail Trade (including motor vehicle repairs)	Retail trade	G511010, G511020, G512100, G512200, G512300, G512400, G512600, G512900, G512510, G512520, G512530, G512540, G512590, G521000, G523100, G523200, G523300, G523400, G523500, G524100, G524200, G524300, G524400, G524500, G522100, G522300, G522200, G525100, G52
18	Accommodation, Cafes and Restaurants	Accommodation	H571010, H571020, H571030, H571040, H571050, H571090
		Bars, clubs, cafes and restaurants	H572000, H574000, H573000
19	Transport and Storage	Road freight transport	I611000
		Road passenger transport	I612100 I612200, I612300, I661100, I661900
		Water and rail transport	I620000, I630100, I630200, I630300, I662100, I662200, I662300. I662900
		Air transport, services to transport and storage	I640100, I640200, I640300, I663000, I664100, I664200, I664300, I664400, I664900, I650100, I650900, I670100, I670900
20	Communication Services	Communication services	J711100, J711200, J712000
21	Finance, Insurance	Finance	K731000, K732100, K732200, K732300, K732400, K732900. K733000. K734000
		Life insurance	K741100
		Superannuation fund operation	K741200
		Health insurance	K742100
		General insurance	K742200
		Services to finance and insurance	K751100, K751900, K752000
22	Property Services	Residential property operators	L771110, L771190pt
		Commercial property operators	L771210, L771290
		Real estate agents	L772000
23	Ownership of Owner Occupied Dwellings	Ownership of owner-occupied dwellings	L771190pt
		Investors in other property	L773010, L773090
		Vehicle and equipment hire	L774100, L774200, L774300
24	Business Services	Scientific research	L781000
		Technical services	L782100, L782200, L782300, L782900
		Computer services	L783100, L783200, L783300, L783400
		Legal services	L784100
		Accounting services	L784200
		Advertising and marketing services	L785100, L785200, L785300
		Business administrative and management services	L785400, L785500
		Employment, security and investigative services	L786100, L786200, L786300, L786400
		Pest control and cleaning services	L786500, L786600
		Other business services	L786700, L786900

Table B.1 (continued)

	29 industries	126 industries	ANZSIC
25	Government	Central government administration	M811100, M813000
		Defence	M820000
		Public order and safety services	M812000, Q963100, Q963200, Q963300
		Local government administration services and civil defence	M811300
26	Education	Pre-school education	N841000
		Primary and secondary education	N842100, N842300, N842400, N842200
		Post school education	N843100, N843200
		Other education	N844000
27	Health and Community Services	Hospitals and nursing homes	O861100, O861200, O861300
		Medical, dental and other health services	O862100, O862200, O862300, O863100, O863200, O863300, O863500, O863600, O863900
		Veterinary services	O864000
		Child care services	O871000
		Accommodation for the aged	O872100
		Other community care services	O872200, O872900
28	Cultural and Recreational Services	Motion picture, radio and TV services	P911100, P911200, P911300, P912100, P912200
		Libraries, museums and the arts	P921000, P922000, P923100, P923900, P924100, P924200, P925100, P925200, P925900
		Horse and dog racing	P931110, P931120
		Lotteries, casinos and other gambling	P932100, P932200, P932900
		Other sport and recreational services	P931200, P931900, P933000
29	Personal and Other Community Services	Personal and other community services	Q951100, Q951900, Q952100, Q952200, Q952300, Q952400, Q952500, Q952600, Q952900, Q970000, Q961000, Q962100, Q962200, Q962900
		Waste disposal, sewerage and drainage services	Q963400, D370200

Note: The four digit ICT producing industries are underlined (see also Appendix Table B.2).
Source: Statistics New Zealand (2001).

Table B.2: The 17 Four-Digit Level ICT Producing Industries making up the ICT Sector and their Employment Shares at the Two-Digit Level

	ICT-producing manufacturing industries	ANZSIC
12	**Machinery and Equipment Manufacturing**	
	List of ICT-producing industries used for disaggregation	
	Professional and Scientific Equipment Manufacturing nec	C283900
	Computer and Business Machine Manufacturing	C284100
	Telecommunication, Broadcasting and Transceiving Equipment Manufacturing	C284200
	Electronic Equipment Manufacturing nec	C284900
	Electric Cable and Wire Manufacturing	C285200
	Share of Employment of ICT-producing industries used for disaggregation	10.5%
	ICT-producing service industries	**ANZSIC**
16	**Wholesale Trade**	
	List of ICT-producing industries used for disaggregation	
	Professional Equipment Wholesaling	F461200
	Computer Wholesaling	F461300
	Business Machine Wholesaling nec	F461400
	Electrical and Electronic Equipment Wholesaling nec	F461500
	Share of Employment of ICT-producing industries used for disaggregation	17.0%
20	**Communication Services**	
	List of ICT-producing industries used for disaggregation	
	Telecommunication Services	J712000
	Share of Employment of ICT-producing industries used for disaggregation	38.9%
23	**Machinery and Equipment Hiring and Leasing**	
	List of ICT-producing industries used for disaggregation	
	Renting of Office Machinery and Equipment (including Computer)	L774300
	Share of Employment of ICT-producing industries used for disaggregation	57.3%
24	**Business Services**	
	List of ICT-producing industries used for disaggregation	
	Data Processing Services	L783100
	Information Storage and Retrieval Services	L783200
	Computer Maintenance Services	L783300
	Computer Consultancy Services	L783400
	Share of Employment of ICT-producing industries used for disaggregation	9.3%
28	**Cultural and Recreational Services**	
	List of ICT-producing industries used for disaggregation	
	Radio Services	P912100
	Television Services	P912200
	Share of Employment of ICT-producing industries used for disaggregation	15.8%

Source: Statistics New Zealand (2001) and INFOS database.

Table B.3: List of the 166 Imported Non-ICT Commodities and 5 Imported ICT Commodities

	Non-ICT commodities		Non-ICT commodities
1	Vegetables	51	Fruit juices
2	Pipfruit	52	Prepared fruit and nuts
3	Kiwifruit	53	Oils and fats
4	Other fruit and nuts	54	Grain products
5	Oil seeds	55	Starches
6	Plants, flowers, seeds	56	Animal feedings
7	Raw vegetable materials	57	Bakery products
8	Sheep	58	Sugar
9	Cattle	59	Confectionery
10	Wool	60	Macaroni and noodles
11	Grain and other crops	61	Other food products
12	Beverage and spice crops	62	Spirits, wines, beer, tobacco
13	Unmanufactured tobacco	63	Soft drinks, bottled water
16	Poultry	64	Natural textiles
17	Deer	65	Cotton textiles
18	Other livestock	66	Man-made fibres and textiles
19	Other animal products	67	Yarn and thread
21	Forestry and logging	68	Woven fabrics
22	Natural gums	69	Other textiles
24	Other forestry products	70	Carpets
26	Fish	71	Twine, rope, netting
27	Crustaceans	72	Tanned skins and leather
28	Fishing services	73	Knitted fabrics
30	Coal	74	Clothing
31	Metal ores	75	Handbags and articles of leather
32	Building stone	76	Footwear
33	Gypsum and limestone	77	Wood
34	Sand, pebbles, gravel, clay	78	Panels and boards
35	Chemical and fertilizer minerals	79	Veneer sheets and plywood
36	Salt	80	Builders joinery
37	Precious metals and stones	81	Wood containers
38	Services incidental to mining	82	Other wood products
40	Crude petroleum and natural gas	83	Pulp, paper and paperboard
42	Meat and meat products	84	Non metal wastes and scraps
44	Bacon, ham and smallgood products	85	Books and stationery
45	Hides and skins	86	Prepared printing plates
46	Processed milk and cream	87	Newspapers and journals
47	Yoghurt, buttermilk, icecream	88	Petroleum products
48	Other dairy products	89	Industrial chemicals
49	Prepared fish	90	Other chemical products
50	Prepared vegetables	91	Plastics

Table B.3 (continued)

	Non-ICT commodities		Non-ICT commodities
92	Rubber	138	Electricity
93	Rubber tyres	140	Water
94	Paints	143	Non-residential building construction
95	Pharmaceutical products	148	Electrical installation work
96	Soap and perfumes	152	Wholesale trade
97	Fertilisers	154	Repair services to machinery and equipment
98	Pesticides	155	Accommodation
99	Glass and glass products	156	Meal services
100	Cement, lime and plaster	159	Road passenger transport
101	Articles of concrete and stone	162	Sea, water and rail services
	Other mineral products		Air transport, other transport and storage services
102		163	
103	Metal wastes	165	Finance
104	Iron and steel	166	Life insurance
105	Other metals	167	Superannuation services
106	Structural metal products	168	Health insurance
107	Tanks, reservoirs and containers	169	General insurance
108	Steam generators	170	Services to finance and insurance
109	Other fabricated metal products	171	Leased commercial property services
110	Engines	175	Equipment hire
111	Motor vehicles and parts	177	Legal services
112	Coachwork	178	Accounting services
113	Ships	180	Architectural and engineering services
114	Pleasure and sporting boats	181	Advertising and marketing
115	Other transport equipment	182	Management consultancy
116	Aircraft and parts	183	Research and development
117	General industrial machinery	184	Placement and supply of personnel
118	Machinery for textile production	186	Cleaning
119	Agricultural and forestry equipment	187	Photographic services
120	Machinery for mining	188	Other business services
121	Machinery for food production	193	Primary education
122	Domestic appliances	194	Secondary education
123	Office equipment	195	Higher education
125	Electric equipment	196	Other education services
126	Audio and video records and tapes	197	Hospital and nursing care
127	Watches and clocks	198	Medical, dental and other health services
128	Medical equipment	206	Sport and recreation services
129	Photographic and scientific equipment	207	Other personal and other community services
130	Furniture	209	Waste disposal
131	Jewellery	210	Direct purchases abroad by residents
132	Musical instruments		ICT commodities
133	Sports goods	124	Computers and parts
134	Games and toys	164	Communication services
135	Prefabricated buildings	176	Computer software and services
136	Other manufactured articles	203	Motion picture, radio, TV services
137	Services incidental to manufacturing	204	News agency services

Source: Statistics New Zealand (2001).

REFERENCES

Ahmad, N., Lequiller, F., Marianna, P., Pilat, D., Schreyer, P. and A. Wölfl (2003), Comparing Labour Productivity Growth in the OECD Area: The Role of Measurement, STI Working Paper 2003-14, Directorate for Science, Technology and Industry, OECD, Paris.

Ark, B. van (2002), "Measuring the New Economy: An International Comparative Perspective", *Review of Income and Wealth*, Series 48, No. 1, March, pp. 1-14.

Ark, B. van, Inklaar, R. and R. McGuckin (2002), "Changing Gear" - Productivity, ICT and Services Industries: Europe and the United States, Research Memorandum GD-60, Groningen Growth and Development Centre, University of Groningen, Groningen. www.eco.rug.nl/ggdc/pub/ online/gd60(online).pdf

Australian Bureau of Statistics (1996), Australian and New Zealand Standard Commodity Classification (ANZSCC), Canberra. http://www.abs.gov.au/AUSSTATS/abs%40.nsf/66f306f503e529a5ca25697e0017661f/c38a4791eaf4d269ca25697e00184c58!OpenDocument

Baily, M. N. and R. Lawrence (2001), "Do We have a New E-conomy?", *The American Economic Review – Papers and Proceedings,* Vol. 91, No. 2, pp. 308-312.

Bar-Shira, Z., Finkelshtain, I. and A. Simhon (2003), "Cross-Country Productivity Comparisons: The "Revealed Superiority" Approach", *Journal of Economic Growth*, Vol. 8, No. 3, pp. 301-323.

Basu, S., Fernald, J., Oulton, N. and S. Srinivasan (2003) The Case of the Missing Productivity Growth: Or, Does Information Technology Explain Why Productivity Accelerated in the United States but not the United Kingdom?, NBER Working Paper 10010, Cambridge, MA, October.

Black, M., Guy, M. and N. McLellan (2003a), "Productivity in New Zealand 1988 to 2002", *New Zealand Economic Papers*, Vol. 37, No. 1, pp.119-150.

Black, M., Guy, M. and N., McLellan, (2003b), Productivity in New Zealand 1988 to 2002, Treasury Working Paper 03/06, Wellington. http://www.treasury.govt.nz/workingpapers/2003/03-06.asp

Brynjolfsson, E. and L. Hitt (2000), "Beyond Computation: Information Technology, Organizational Transformation and Business Performance", *Journal of Economic Perspectives*, Vol. 14, No. 4, pp. 23-48.

David, P. (1990), "The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox", *American Economic Review*, Vol. 80 No. 2 (Papers and Proceedings), pp. 355-361.

Daveri, F. (2003), "Information Technology and Productivity Growth Across Countries and Sectors", in Derek Jones (ed.), *New Economy Handbook*, Elsevier/Academic Press: San Diego and London, pp. 101-120.

Diewert, E. and Lawrence, D. (1999), Measuring New Zealand's Productivity, Treasury Working Paper 99/5, Wellington. http://www.treasury.govt.nz/workingpapers/1999/95-5.asp

Färe, R., Grosskopf, S. and D. Margaritis (2003), "Productivity Growth in New Zealand: 1978-1998", *New Zealand Economic Papers*, Vol. 37, No. 1, pp. 93-118.

Frederick, H. and D. McIlroy (1999), *The Knowledge Economy*, The New Zealand Internet Institute, Wellington. Also available as: A submission to the New Zealand Government by the Minister for Information Technology's IT Advisory Group, at: http://www.med.govt.nz/pbt/infotech/knowledge_economy/index.html.

Galt, D. (2000), New Zealand's Economic Growth, Treasury Working Paper 00/09, Wellington. http://www.treasury.govt.nz/workingpapers/2000/00-09.asp

Gordon, R. (2000), "Does the "New Economy" Measure up to the Great Inventions of the Past?", *Journal of Economic Perspectives*, Vol. 14, No. 4, Fall, pp. 49-74.

IMF (2003), "New Zealand Selected Issues", *IMF Country Report No. 03/122*, International Monetary Fund, Washington.

Knuckey, S., Johnston, H., Campbell-Hunt, C., Carlaw, K., Corbett, L. and C. Massey (2002), Firm Foundations 2002: A Study of New Zealand Business Practices & Performance, Ministry of Economic Development, Wellington. http://www.med.govt.nz/irdev/ind_dev/firm-foundations/ index.html

Mawson, P., Carlaw, K. and N. McLellan (2003), Productivity Measurement: Alternative Approaches and Estimates, Treasury Working Paper 03/12, Wellington. http://www.treasury.govt.nz/workingpapers/2003/03-12.asp

Ministry of Economic Development (2003), Growth and Innovation Framework: Benchmark Indicators Report 2003, Wellington. http://www.med.govt.nz/irdev/econ_dev/growth-innovation/progress-2003/benchmark/

NOIE (2004), Productivity Growth in Australian Manufacturing, NOIE Occasional Economic Paper, The National Office for the Information Economy, Canberra. http://www.noie.gov.au

OECD (2002), *Measuring the Information Economy 2002*, Paris.

OECD (2003a), *Seizing The Benefits of ICT in a Digital Economy*, Meeting of the OECD Council at Ministerial Level 2003, Paris.

OECD (2003b), *OECD Science, Technology and Industry Scoreboard 2003 – Towards a Knowledge-Based Economy*, Paris.

OECD (2003c), *ICT and Economic Growth: Evidence from OECD Countries, Industries and Firms*, OECD: Paris.

OECD (2004), *OECD Economic Surveys: New Zealand, Volume 2003 Supplement 3*, Paris.

Parham, D., Roberts, P. and H. Sun (2001), Information Technology and Australia's Productivity Surge, Staff Research Paper, Productivity Commission, Canberra. http://www.pc.gov.au/research/staffres/itaaps/

Razzak, W. (2003), Towards Building a New Consensus About New Zealand's Productivity, Department of Labour, Wellington, January. http://www.dol.govt.nz/publication-view.asp?ID=139

Scarpetta, S., Bassanini, A., Pilat, D. and Schreyer, P. (2000), Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level, Economics Department Working Papers No. 248, Organization for Economic Co-operation and Development.

Schreyer, P. (2000), The Contribution of Information and Communication Technology to Output Growth: A Study of the G7 Countries, STI Working Paper 2000/2, OECD, Paris.

Shapiro, M. (2003), Has the Rate of Economic Growth Changed? Evidence and Lessons for Public Policy, Reserve Bank of New Zealand Discussion Paper DP2003/07, Wellington. http://www.rbnz.govt.nz/research/discusspapers/ dp03_07.pdf

Simon, J. and S. Wardrop (2002), Australian Use of Information Technology and Its Contribution to Growth, Research Discussion Paper 2002-02, Economic Research Department, Reserve Bank of Australia, Canberra.

Statistics New Zealand (2000), *"Hot off the Press, Upgraded National Accounts 2000, Commentary Notes"*, Wellington.

Statistics New Zealand (2001), *"Inter-Industry Study 1996 – 126 Industries – Interim Release"*, Wellington.

Statistics New Zealand (2003), *"Hot off the Press: Gross Domestic Product, September 2003 Quarter, Technical Notes"*, Wellington.

Stiroh, K. (2002a), "Information Technology and the U.S. Productivity Revival: What Do the Industry Data Say?", *American Economic Review*, Vol. 92, No. 5, pp. 1559-1576.

Stiroh, K. (2002b), "Are ICT Spillovers Driving the New Economy?", *Review of Income and Wealth*, Series 48, No. 1, March, pp. 33-57.

The Treasury (2004), New Zealand Economic Growth: An Analysis of Performance and Policy, Wellington, April. http://www.treasury.govt.nz/release/economicgrowth/

United Nations (1999), *Handbook of National Accounting: Input-Output Table Compilation and Analysis*, Series F, No. 74 (E99.XVII.9), United Nations Statistics Division, United Nations, New York.

Whistler, D., White, K., Wong, D. and D. Bates (2001), *Shazam Econometric Software Version 9: User's Reference Manual*, Northwest Econometrics, Vancouver.

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