The Contribution of ICT-Producing and ICT-Using Industries to Productivity Growth: A Comparison of Canada, Europe and the United States

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The explosive growth of investment in information and communication technology (ICT) has been at the centre of the "new economy" hype. While the slowdown in GDP growth since 2000 has dampened investment in ICT in Europe and North America alike, the contribution of ICT investment to economic performance should not be assessed solely on the basis of a cyclical slowdown in investment. In fact, recent analysis suggests that the structural forces of the late 1990s are still in place, despite the slowdown in growth on both sides of the Atlantic.[1]

However, when looking back at the 1990s, one finds evidence of a divide between North America and Europe. While productivity growth accelerated in both Canada and the United States, growth in most European countries slowed down during the second half of the 1990s. The average annual growth rate of labour productivity, measured as gross domestic product per person employed, in Canada accelerated from 1.3 per cent in 1990-1995 to 1.8 per cent in 1995-2000 and in the United States from 1.1 to 2.5 per cent. In contrast, productivity growth in the European Union fell from 1.9 per cent in 1990-1995 to 1.4 per cent in 1995-2000 (See Table 1).[2]

The acceleration of productivity growth in the United States has been widely attributed to the rapid increase in investment in information and communication technology (OECD, 2001). Some have stressed that this growth acceleration is to a large extent due to improved productivity growth in the ICT-producing sector (Jorgenson, 2001). Others have demonstrated an increasingly productive use of ICT goods and services elsewhere in the economy (Baily, 2002; Oliner and Sichel, 2002).

While the impact of ICT on U.S. growth has been studied most extensively, more growth accounting studies on Canada and the European Union have begun to appear as well.[3] The main message from these studies is that in almost all countries ICT is making an increasing contribution to productivity growth when comparing the second half of the 1990s to the first half. However, the contribution of ICT is much larger in the United States than in most other countries. So a mixed picture emerges about growth in Canada when looking at the aggregate level. On the one hand, labour productivity growth accelerated during the 1990s, but ICT investment seems to have played a much less important role in explaining this acceleration than in the United States.

To better understand what is causing these differences it is necessary to look beyond the aggregate picture and study growth at the industry level. Because we lack data for ICT investment at the industry level for many countries, our focus here is on labour productivity rather than total factor productivity. Moreover, our estimates are for value added per person employed rather than value added per hour worked.

In the next sections we describe our database on labour productivity growth at the industry level and introduce a distinction between industries that produce ICT, those that intensively use ICT and those that do not use ICT very intensively (the "non-ICT" industries). In section three we look at labour productivity growth in several industry groups and at their contribution to aggregate productivity growth. We end with some concluding remarks.

Data and Sources

For the analysis of productivity and employment growth in Europe and the United States, we have developed a database which contains information on value added and employment in 16 OECD countries for 51 industries between 1990 and 2000.[4] The point of departure in this database is the new OECD STAN Database on national accounts. The STAN Database contains information on the most important national accounts variables from 1970 onwards on a common industrial classification.[5] The level of detail must be very disaggregated to adequately distinguish between ICT-producing and ICT-using industries. Hence for the level of detail used in this paper, only data for the period from 1990 onwards are available so far. In addition, STAN was supplemented with industry detail from national production surveys and services statistics covering production industries, distribution and services. In general, the method employed was to use STAN aggregates as control totals and the additional data to divide these totals over the more detailed industries.

Three major groups of industries are distinguished: ICT-producing industries, ICT-using industries (which excludes ICT-producing industries) and "non-ICT" industries (which represent industries that use ICT less intensively). The first group of ICT-producing industries, including producers of IT hardware, communication equipment, telecommunications and computer services (including software), was distinguished based on an OECD classification (see for example OECD, 2002). The second and third groups are distinguished in terms of their intensity of use of ICT. This is a less straightforward undertaking since nearly every part of the economy uses some ICT. As a measure of ICT intensity, we rely on the share of ICT capital in total capital services in the United States from Stiroh (2002). Using these data, the top half of industries is classified as ICT-using and the bottom half as non-ICT.[6]

There are two reasons for applying the classification based on ICT investment intensity in the United States to all countries. The first relates to the very limited availability of data on ICT investment by industry outside the United States.[7] Secondly, given the leading role of the United States, it is reasonable to assume that the distribution of ICT use in that country presents a set of technological opportunities, which may or may not have been taken up in other countries. We also make a distinction between manufacturing and services industries within each industry.

Before moving on, two important measurement problems need to be addressed: the method of aggregation and the deflation of ICT goods output. At present, many countries still use fixed-weight (Laspeyres) indices to calculate aggregate value added at constant prices. This can lead to serious substitution bias if the structure of the economy is changing rapidly over time. To correct

for this problem, we calculate chain-weighted indices for all aggregated real output series to ensure consistency across countries. This means that our estimates for GDP will generally not conform to those from national statistical offices.

Another problem is the deflation of ICT goods. It is well known that the capabilities of semiconductors and computers have improved tremendously over the past few decades. Since consumers can buy computers with vastly more computing power at comparable prices, the real price of computing power has declined continuously. However, traditional methods of sampling and quality adjustment in calculating price indices for these goods will almost certainly lead to an underestimation in the rate of the output price decline. There are currently only a few countries, such as the United States, Canada and France that have an adequate system in place for measuring prices of computers and semiconductors. This means that measured productivity growth in ICT-producing industries in all other countries is likely to be much slower. We avoid this downward bias by applying a harmonisation procedure, which consists of applying the U.S. deflators for each of the ICT-producing manufacturing industries to all other countries after making a correction for the general inflation level.[8] Although this influences the productivity growth rates in the ICT-producing industries, we show that it does not have a large effect on the aggregate growth figures due to the relatively small weight of this sector in the total economy.

Productivity Growth at the Industry Level

In Table 1 we show labour productivity growth for a number of major industry groups in Canada, the European Union and the United States over the period 1990-95 and 1995-2000.[9] The aggregate picture hides a wide variety of growth patterns at the industry level. The first pattern that stands out is that productivity growth in ICT-producing industries is much higher than in nearly all other industry groups. This is largely due to the extremely high growth rates in ICT-producing manufacturing industries. Although this is partly due to the fact that U.S. price deflators are used to deflate output in these industries, the pro-memoria lines in Table 1 show that this picture holds even when using deflators from each country's own national accounts. The rapid productivity growth in ICT-producing manufacturing can be further traced to growth in the computer and semiconductor industries, with comparatively much slower growth in the rest of the ICT-producing manufacturing industries (see Appendix Table 1).

The difference between the United States, on the one hand, and both Canada and the EU on the other, becomes especially clear when looking at the contributions of the ICT-producing industries to aggregate productivity growth.[10] This contribution has been much higher in the United States during both halves of the 1990s. Once again, this is mainly the case in the ICT-producing manufacturing industries, which contributed nearly 0.7 per cent to U.S. labor productivity growth between 1995 and 2000 but only between 0.2 and 0.3 in the EU and Canada. In ICT-producing services, which include telecommunication and computer services, the differences are much smaller and here the United States even lags behind.

The ICT-producing industries make up only a relatively small part of the economy. For a complete picture of the growth differences we need to look at the ICT-using and non-ICT industries as well. Table 1 shows that most of the aggregate acceleration in U.S. productivity growth can be traced to the ICT-using services industries. Productivity growth in these industries accelerated from 1.9 per cent per year between 1990 and 1995 to 5.4 per cent in the last half of the 1990s. The contribution to aggregate labour productivity growth in the United States

Table 1

Annual Average Growth in Value Added Per Person Employed, Contribution to Aggregate Growth and Value Added Shares in Canada, European Union and United States, by Major Industry Groups

(percentage points)

	Productivity growth						Contributions to aggregate productivity growth[b]						Nominal GDP share		
	1990-1995			1995-2000			1990-1995			1995-2000			2000		
	Canada	EU[d]	U.S.	Canada	EU	U.S.	Canada	EU[d]	US	Canada	EU[d]	US	Canada	EU[d]	U.S.
Total Economy[a]	**1.3**	**1.9**	**1.1**	**1.8**	**1.4**	**2.5**	**1.32**	**1.86**	**1.07**	**1.76**	**1.40**	**2.49**	**100.0**	**100.0**	**100.0**
ICT-Producing Industries[a]	**1.6**	**6.7**	**8.1**	**7.1**	**8.7**	**10.1**	**0.08**	**0.33**	**0.51**	**0.42**	**0.46**	**0.74**	**6.4**	**5.8**	**7.2**
ICT-Producing Manufacturing[a]	10.5	11.1	15.1	21.8	13.8	23.7	0.10	0.17	0.40	0.27	0.21	0.67	1.6	1.5	2.6
ICT-Producing Services	-0.4	4.4	3.1	3.3	6.5	1.8	-0.01	0.15	0.11	0.15	0.25	0.07	4.8	4.3	4.7
ICT-Using Industries	**2.0**	**1.7**	**1.5**	**3.2**	**1.6**	**4.7**	**0.52**	**0.42**	**0.43**	**0.83**	**0.41**	**1.40**	**27.1**	**27.0**	**30.7**
ICT-Using Manufacturing	1.6	3.1	-0.3	3.1	2.1	1.2	0.07	0.20	-0.01	0.14	0.13	0.05	5.1	6.0	4.3
ICT-Using Services	2.1	1.1	1.9	3.2	1.4	5.4	0.45	0.22	0.44	0.69	0.29	1.35	22.0	21.0	26.3
Non-ICT Industries	**1.0**	**1.6**	**0.2**	**0.8**	**0.7**	**0.5**	**0.77**	**1.08**	**0.23**	**0.52**	**0.47**	**0.36**	**66.5**	**67.2**	**62.1**
Non-ICT Manufacturing	3.4	3.8	3.0	0.7	1.5	1.4	0.38	0.50	0.31	0.09	0.18	0.13	13.0	12.0	9.3
Non-ICT Services	0.4	0.6	-0.4	0.4	0.2	0.4	0.17	0.25	-0.15	0.17	0.08	0.18	38.9	44.8	43.0
Non-ICT Other	1.3	2.7	0.7	1.8	1.9	0.6	0.22	0.34	0.07	0.27	0.21	0.05	14.6	10.4	9.8
Shift effect[b]							-0.04	0.03	-0.10	-0.01	0.05	-0.01			
Pro-memoria: productivity growth with national deflators															
Total Economy[c]	1.3	1.9	1.1	1.7	1.4	2.5									
ICT-Producing Manufacturing[c]	9.7	7.8	15.1	13.0	10.1	23.7									

Note: (a) U.S. deflators for office and computer equipment and for communication equipment are applied.

(b) Contributions are calculated on the basis of a shift-share analysis which decomposes aggregate productivity growth into the contributions of industries by weighing an industry's productivity growth by its employment share. Contributions of industry groups refer to the "intra-effect" only, that is the weighted average productivity growth of the group. The "shift-effect", which refers to the effect of reallocations between groups on aggregate productivity growth, is reported separately.

(c) National deflators for office and computer equipment and for communication equipment are applied.

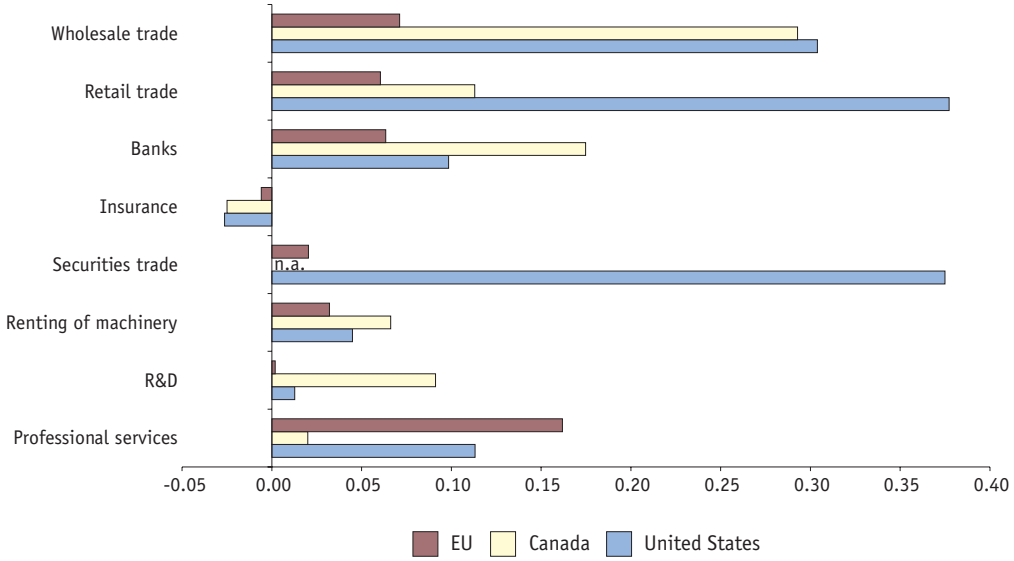
(d) EU includes Austria, Denmark, Finland, France, Germany, Ireland, Italy, Netherlands, Spain, Sweden and the United Kingdom, which represents over 90% of EU GDP.

Source: Based on van Ark et al. (2002a).

Chart 1

Contributions to Aggregate Productivity Growth in the ICT-using Services Industries, 1995-2000

(average annual percentage points)



rose by a full percentage point. The European Union did not experience such a large improvement in productivity growth in ICT-using services with only a 0.3 percentage point acceleration in growth. Canada occupies an intermediate position. Productivity growth in ICT-using services accelerated from 2.1 to 3.2 per cent but less so than in the United States. The contribution of ICT-using services in Canada increased from 0.45 out of 1.3 percent productivity growth from 1990-1995 to 0.69 out of 1.9 percent productivity growth between 1995 and 2000.

Differences in productivity growth rates between countries are much smaller in the non-ICT industries throughout the 1990s. Productivity growth in this industry group is slower than in ICT-producing and ICT-using industries. It even decelerated somewhat in Canada, although by not as much as in Europe. Productivity growth in non-ICT manufacturing industries decelerated in tandem in Canada and Europe, but growth in non-ICT services remained constant in Canada while decelerating in Europe.

Still, ICT-using services are responsible for more than half of the acceleration in productivity growth in both Canada and the United States. The difference in productivity growth between Canada and the United States in 1995-2000 can be almost entirely explained by the higher contribution of this sector in the United States. In Chart 1 we display the contribution of the individual ICT-using services industries to aggregate productivity growth between 1995 and 2000.[11] This Chart shows which U.S. industries have taken the lead, namely wholesale, retail trade and securities industries. The contribution of wholesale trade in Canada is comparable to that in the United States, and Canada showed higher growth contributions in banking, renting of machinery and research and development. However, the overall gap with the United States is due to smaller contributions from retail trade and professional services. Still the gap between Canada and the United States is much less pronounced than between Europe and the United States, in the contribution of both ICT-producing manufacturing and of ICT-using services.

Concluding Remarks

The growth experience of Canada is somewhere in between that of Europe and the United States. While labour productivity growth accelerated during the second half of the decade, it remained slower in Canada than in the United States. This was partly due to a smaller contribution to productivity growth of the ICT-producing manufacturing industries, but, more importantly, to slower productivity growth in ICT-using services industries. Still productivity growth was clearly faster in Canada than in Europe, most noticeably in ICT-using services. This raises the important question of why Canada was able to improve its growth performance in key ICT-using industries such as wholesale trade, but failed to do the same in others such as retail trade. Part of the answer may be related to less ICT investment in these industries, but this can only be assessed on the basis of detailed analysis of ICT investment shares by share. Another possibility is that the organizational innovations that accompany ICT investments have been insufficient.[12]

Still the results presented in this paper suggest that Canada has been taking greater advantage of the possibilities offered by ICT to improve efficiency in many industries than Europe has. Although productivity growth has not accelerated to the same extent as in the United States, Canada clearly leaves Europe behind. Part of the explanation for this 'intermediate' position may lie in the regulatory environment. According to the OECD Regulation Database, Canadian product and labour market regulations are more strict than in the United States, but less restrictive than in the European Union. However, the underlying causes of the differences in productivity growth are likely to be complex.

Notes

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1 See McGuckin and van Ark (2003). In 2001 growth of GDP per hour worked in the United States fell to 0.4 per cent followed by a strong recovery in 2002 at 2.8 percent. In the EU, productivity growth remained relatively high at 1.3 per cent in 2001, but it slowed to 0.5 per cent in 2002. These differences are largely related to a different timing in the economic downturn since 2000.

2 These estimates are somewhat different from those published in 2002 by McGuckin and van Ark (2002) and van Ark (2002). It should be stressed, however, that the earlier estimates which show a slowdown in labour productivity growth in Canada, are based GDP per hour worked rather than GDP per person employed. In this paper we do not report estimates based on hours, as these are missing at industry level for many of the European countries. Even so, the present estimates of GDP per person employed in Canada show faster growth compared to the earlier estimates. This is mainly due to a revision of the Canadian GDP growth rates which are now based on the recently completed benchmark real output estimates for the 1997 Input-Output table.

3 For a growth accounting exercise for the European Union see van Ark *et al.* (2002b). For Canada, see Harchaoui *et al.* (2002), Khan and Santos (2002) and Colecchia and Schreyer (2002).

4 The underlying data material and further analysis are described in more detail in van Ark *et al.* (2002a).

5 The STAN Database uses the international classification ISIC revision 3. This classification is very similar to the one European countries use. For the United States, on the other hand, much effort has to be put into reconciling differences in industrial classification, see Appendix B of van Ark *et al.* (2002a).

6 The exceptions are the education and health sectors which rank fairly high in terms of their ICT capital share, but near the bottom on alternative measures such as ICT capital per worker or per unit of output. Results are qualitatively similar if these industries were included as ICT-using, however.

7 See van Ark *et al.* (2002b) for discussion of the difficulties in acquiring ICT investment even for the aggregate European economies.

8 See van Ark *et al.* (2002a) for details on this method and Triplett (1996) for the importance of double deflation in the computer and semiconductor industries.

9 In Table 1, productivity is defined as GDP per person employed. If we were to look at GDP per hour worked, aggregate productivity growth in Canada would be slower between 1995 and 2000 but the overall industry pattern is similar.

10 For this purpose we have employed a shift-share analysis which decomposes aggregate productivity growth into the contributions of industries by weighing an industry's productivity growth by its employment share. The effect on aggregate productivity growth of reallocations of employment between industries is reported separately in Table 1 as the "shift-effect". See van Ark *et al.* (2002a) for more details.

11 See Appendix Table 1 for the productivity growth rates of these industries. The sum of the contributions from Chart 1 does not add up to the growth rates in Table 1 because the contributions in Chart 1 include the shift-effect (see footnote 10).

12 See, for example, Brynjolfsson and Hitt (2000) for a review of the link between ICT and organizational innovations in the United States.

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Appendix Table 1

Growth in Value Added Per Person Employed and Value Added Shares in Canada, the European Union and the United States, by Industry (average annual rate of change)

	ISIC rev 3	Productivity growth 1990-1995			1995-2000			Value added share 2000		
		Canada	EU	U.S.	Canada	EU	U.S.	Canada	EU	U.S.
Total Economy		**1.3**	**1.9**	**1.1**	**1.8**	**1.4**	**2.5**	**100.0**	**100.0**	**100.0**
ICT-Producing Industries		**1.6**	**6.7**	**8.1**	**7.1**	**8.7**	**10.1**	**6.4**	**5.9**	**7.3**
ICT-Producing Manufacturing		**10.5**	**11.1**	**15.1**	**21.8**	**13.8**	**23.7**	**1.6**	**1.6**	**2.6**
Computers	30	22.8	33.2	28.6	64.1	49.3	52.3	0.1	0.2	0.4
Fiber optics	31.3	2.5	6.9	5.6	-1.8	2.9	5.7	0.1	0.1	0.2
Semiconductors	32.1	35.5	37.7	36.8	64.7	56.4	52.1	0.3	0.2	0.8
Communication eq.	32.2	7.5	5.0	6.6	6.8	3.5	-0.4	0.7	0.4	0.6
Radio and TV eq.	32.3	4.5	-2.6	-4.6	1.4	-13.9	-12.5	0.0	0.1	0.1
Instruments	33.1	2.0	-2.6	-4.5	3.9	-7.2	-5.9	0.4	0.5	0.6
ICT-Producing Services		-0.4	4.4	3.1	3.3	6.5	1.8	4.8	4.3	4.7
Telecommunications	64	2.1	5.7	3.3	6.7	9.9	6.5	2.9	2.5	2.5
Computer services	72	0.1	1.5	2.7	3.3	1.5	-4.5	1.9	1.8	2.1
ICT-Using Industries		**2.0**	**1.7**	**1.5**	**3.2**	**1.6**	**4.7**	**27.1**	**27.0**	**30.6**
ICT-Using Manufacturing		**1.6**	**3.1**	**-0.3**	**3.1**	**2.1**	**1.2**	**5.1**	**5.9**	**4.3**
Apparel	18	4.2	5.2	3.4	-0.7	2.9	3.8	0.3	0.4	0.2
Printing & Publishing	22	-6.2	1.9	-2.6	10.2	2.5	-0.2	1.6	1.3	1.1
Machinery	29	5.2	4.2	0.9	-0.2	1.0	0.3	1.2	2.0	1.4
Electrical machinery	31-31.3	6.6	2.2	0.5	0.5	2.3	-0.7	0.3	0.8	0.2
Watches & instruments	33-33.1		7.5	2.1		5.1	14.2		0.1	0.1
Ships	351	8.0	4.1	-3.8	-8.0	0.4	-0.2	0.0	0.1	0.1
Aircraft	353	-0.9	0.5	-1.0	3.8	6.4	1.1	0.6	0.3	0.5
Railroad and other	352+359	9.4	5.9	-2.0	-4.7	3.1	-0.1	0.2	0.1	0.1
Misc. manufacturing	36-37	3.1	1.1	1.3	2.1	1.5	2.4	0.8	0.8	0.6
ICT-Using Services		**2.1**	**1.1**	**1.9**	**3.2**	**1.4**	**5.4**	**22.0**	**21.1**	**26.3**
Wholesale trade	51	2.7	2.9	3.4	4.6	1.2	6.1	6.0	4.7	5.8
Retail trade	52	1.6	1.1	2.3	2.1	1.4	6.9	5.3	4.8	6.3
Banks	65	3.8	0.4	1.3	4.2	3.0	2.8	5.4	3.6	4.5
Insurance	66	1.9	0.2	3.0	1.6	0.2	-1.0	1.6	0.9	1.6
Securities trade	67		1.1	3.2		2.0	15.3		0.7	2.2
Renting of machinery	71	-1.4	2.4	6.7	3.9	0.5	5.7	0.8	1.1	0.7
R&D	73	0.1	-0.2	1.0	3.3	-0.5	3.1	1.8	0.5	0.5
Professional services	74.1-74.3	-0.7	-0.4	-0.7	1.4	0.4	1.0	1.2	4.7	4.7
Non-ICT Industries		**1.0**	**1.6**	**0.2**	**0.8**	**0.7**	**0.5**	**66.5**	**67.1**	**62.1**
Non-ICT Manufacturing		**3.4**	**3.8**	**3.0**	**0.7**	**1.5**	**1.4**	**13.0**	**11.9**	**9.3**
Food & beverages	15-16	2.2	2.9	3.5	-1.0	0.0	-4.5	2.2	2.3	1.4
Textiles	17	2.4	3.5	3.0	0.9	1.4	3.3	0.3	0.5	0.3
Leather	19	1.1	3.3	4.9	-7.2	0.7	1.3	0.0	0.2	0.0
Wood	20	-1.2	2.5	-2.8	2.3	2.7	0.3	1.1	0.4	0.5
Paper	21	4.3	3.5	0.0	-2.1	2.3	0.2	1.4	0.6	0.6
Petroleum & coal	23	4.3	9.6	5.0	-1.5	0.2	1.5	0.3	0.3	0.4
Chemicals	24	4.9	6.8	3.4	0.4	4.7	4.4	1.4	2.0	2.0
Rubber & plastics	25	5.6	3.2	4.6	1.6	1.6	4.1	0.9	0.9	0.6
Stone, clay & glass	26	0.5	2.5	2.8	3.7	1.4	2.6	0.4	0.9	0.5
Basic metals	27	4.7	6.9	3.9	3.1	0.9	3.1	1.1	0.7	0.5
Fabricated metals	28	2.0	2.2	3.2	2.2	0.9	0.6	1.2	1.7	1.1
Motor vehicles	34	5.4	3.2	4.9	2.8	0.9	1.4	2.7	1.4	1.3
Non-ICT Services		**0.4**	**0.6**	**-0.4**	**0.4**	**0.2**	**0.4**	**38.9**	**44.7**	**43.0**
Repairs	50		-0.1	-1.4		1.0	-2.5		1.9	1.1
Hotels & restaurants	55	-1.3	-1.8	-1.1	0.2	-1.2	0.4	2.4	3.1	2.5
Transportation	60-63	1.8	3.2	2.1	2.2	1.7	1.6	4.2	4.8	3.2
Real estate	70	1.0	-0.7	1.6	0.1	-0.8	1.7	11.4	10.2	10.2
Other business services	74.9	-0.7	-1.1	-1.0	1.4	-0.3	1.4	1.6	3.1	3.4
Government	75	1.2	1.4	0.0	0.6	1.1	0.2	5.5	6.3	12.5
Education	80	-0.6	0.9	-0.2	-1.0	-0.1	-1.2	4.8	4.9	0.8
Health	85	-1.3	0.8	-2.2	-0.1	0.4	-0.3	6.0	6.1	6.5
Personal & social serv.	90-93	-1.1	-0.2	0.3	0.9	-0.5	-0.9	3.0	4.1	2.8
Private households	95		-0.4	2.2		0.0	0.7		0.3	0.1
Extraterritorial organizations	99									
Non-ICT Other		**1.3**	**2.7**	**0.7**	**1.8**	**1.9**	**0.6**	**14.6**	**10.5**	**9.8**
Agriculture	01-05	0.7	5.2	-1.0	0.4	4.0	6.3	2.4	2.2	1.6
Mining	10-14	3.9	7.5	5.4	1.9	3.5	-1.8	4.0	1.1	1.2
Utilities	40-41	0.7	4.5	2.5	2.5	4.9	2.3	3.0	2.0	2.1
Construction	45	-1.4	0.4	0.5	2.1	0.2	0.2	5.3	5.2	4.9

Source: Based on van Ark *et al.* (2002a).